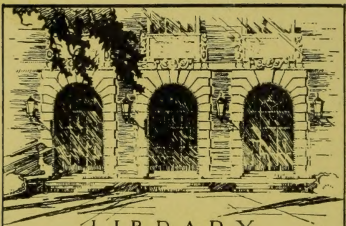

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AN. to DEC., 1910.

OIL

The ILLUMINATING ENGINEER

CETYLENE

GAS

THE·JOURNAL OF SCIENTIFIC

ILLUMINATION

EDITED · BY · LEON · GASTER

Official Organ of the

Illuminating Engineering Society.

(Founded in London, 1909.)

LECTRICITY

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Special Notice.

A glance at the contents sheets of the first three volumes of The Illuminating Engineer must convey some idea of the wideness of the questions with which the publication has dealt.

As may be seen already from the contents of these numbers, we include among our contributors some of the leading authorities, here and on the Continent, on the subject of illumination, who have expressed their appreciation of our aims and promised cordial support and co-operation.

We feel that the response which has followed our appeal for support has fully justified our conviction that illumination is a matter of interest to all sections of the community, and that the subject is of exceptional importance. As mentioned before, we believe that 'The Illuminating Engineer' occupies a field not covered by any other journal. It circulates among many trades and professions, being designed to meet the special needs of: **Architects,** by enabling them to satisfy the demands of their clients for economy and efficiency without sacrificing artistic effect; **Electrical Engineers,** by giving them a complete résumé of all matters pertaining to this important branch of their profession; **Central Station Engineers,** by furnishing them with information which will enable them to increase their business; **Isolated Plant Engineers,** by suggesting ways of making large economies in the use of their illuminants, while actually increasing the illumination of their buildings; **Electrical and Gas Lighting Contractors,** by helping them to detect and remedy faults in lighting systems due to bad placing of lamps, improper use of shades, reflectors, globes, or uneconomical wiring devices; **Gas Company Managers,** by showing them how to extend the use of gas for lighting purposes, and keep abreast with the progress made, so as to meet the constant competition; **Fittings Manufacturers,** by keeping them posted concerning the latest designs and the progressive requirements of architects and illuminating engineers; **Teachers and Students,** by recording the developments in the science and art of illumination, some of which are too recent to be published in text-books; and last, but not least, **Consumers,** by showing them how to get better value for money spent and obtain the highest amount of illumination at the smallest consumption of gas, electric energy, oil, acetylene, or other illuminant.

The Proprietors of 'THE ILLUMINATING ENGINEER.'

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by LEON GASTER

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EDITORIAL.

A Year's Progress.

WITH this number THE ILLUMINATING ENGINEER enters upon its third year of existence. It may, therefore, be opportune to summarize a few of the most important steps in the progress of the illuminating engineering movement in this country during the past year.

The first point that claims our attention is, of course, the formation of the Illuminating Engineering Society. Just a year ago we were speaking of the value of such a body, and expressing the hope that it would soon come into existence. These hopes have now been realized, and the Society is an accomplished fact.

In passing we may refer to its international character. Among our correspondents and vice - presidents are included many who have assisted the journal and helped to uphold the standard of contributions which we have set ourselves to maintain. A glance over the Index for 1909, which is issued with this number, will serve to show that our anticipation that there would be no difficulty in finding plenty of valuable matter to discuss, and that able assistance to do so would be forthcoming, was well founded. The Index also illustrates one respect in which our journal differs in its scope from many periodicals—namely, it is intended to serve not only as a record of current events connected with illumination, but also as a permanent up-to-date source of information thereon, derived through European and American channels, such as no single text-book on the subject could hope to be.

At the commencement of the last year we drew attention to the increase in the space devoted to matters of illumination in the technical press. We might make the same remark, with even

greater justice, on this occasion, for both the extent and the nature of the comments on illuminating engineering have recently again undergone a rapid development. Not only is the subject dealt with by journals of the most varied scope, but the fundamental ideas of illuminating engineering are now much better understood, and appreciated.

There have been other quarters in which the development of interest in lighting questions has been evident. We have remarked, for example, that in the report of H.M. Inspector of Factories for this year a number of comments were made on the existing conditions of illumination in factories and their effect on health. The annual report of Dr. Kerr, Medical Officer to the L.C.C., also lays stress on the important bearing of illumination on the eyesight of school children. It is also gratifying to find that various aspects of illumination tend to occupy a prominent place in the proceedings of different learned and technical societies. An important precedent was formed this year by the Royal Society of Arts in selecting 'Modern Methods of Illumination' as the subject of a series of Cantor Lectures. A lecture with the same title was also included in the course at the London Institution. In addition, several papers before the Institutions of Gas and Electrical Engineers dealt with matters more or less closely connected with lighting, and it was significant that in several of the discussions speakers even went out of their way to allude to matters of importance from the standpoint of illuminating engineering. We have before us the programme for the next year of the Royal Institution, and we note that here also the subject of light and illumination will assume an exceptionally prominent position. Professor S. P. Thompson, the first President of the Illuminating Engineering Society, will, very appropriately, deliver a series of three lectures on 'Illumination, Natural and Artificial.' Mr. Duddell also is to deal with electric lighting in his last lecture, and Professor Sir J. J. Thompson will give a series of six lectures on 'Electric Waves and the Electromagnetic Theory of Light.'

Amongst other notable events of special interest during the year to which brief reference may be made. We may first recall the series of papers presented at the Third Annual Convention of the Illuminating Engineering Society in the United States; these, we think, once more demonstrated not only the extent of the material available, but also the practicability of discussion on perfectly amicable lines.

Our Society is fortunate in possessing the goodwill of the Illuminating Engineering Society in the United States; we reciprocate the desire of our friends in that country for concerted efforts in matters of illumination, and we feel sure that all here will welcome this co-operation. The international agreement between Great Britain, France, and the United States on the question of a common unit of light also seems to us an important precedent, not only because it affords an instance of the tendency towards co-operation between different nations on these matters, but also on account of the fact that the British Committee dealing with the matter included representatives of both the gas and electrical professions working together for a common end.

Speaking with a full knowledge of the various steps leading up to the formation of the Illuminating Engineering Society and the development of the Illuminating Engineering movement in this country, we feel that our supporters have every reason to be satisfied with the progress during 1909, and we hope that they will continue to give us their help and encouragement. With this support we are prepared to push on the work of the new year with fresh vigour, and with every prospect of enduring success.

Ancient Methods of Street-lighting in London.

Two articles in the present number, on pages 13 and 17, deal with the systems of lighting used in past centuries in the Streets of London.

Readers will recall how, in our November number, the history of the Guild of Wax Chandlers was traced from step to step, and how, though they were responsible for certain beneficial regulations to secure the purity of the goods supplied, they occasionally misused their privileges. It is very interesting to observe, in our correspondent's present article, how history repeated itself in the case of the Tallow Chandlers. They, too, instituted a system guaranteeing the perfection of the materials utilized in their candles, but they in turn also made every possible effort to resist the introduction of oil for lighting just as the Wax Chandlers had resented the development of tallow the Century before. We can see how the grant of such monopolies hindered the progress of lighting, and we need not wonder that any new change, however beneficial in itself, is apt to be opposed by the old vested interests in just the same way. Nowadays, when so many alternative methods of illumination are available, marked progress in one branch of lighting rarely fails to call forth corresponding efforts on the part of its rivals, and an unquestionable improvement, which is for the benefit of the public, invariably makes its way. In a subsequent article (p. 17) we reach a yet later stage in the developments of Streetlighting with the formation of the Gas Light and Coke Co. in 1809. Some of the remarks in the old volume to which we refer give us a vivid idea of the original difficulties from which the Gas Light and Coke Co. eventually emerged triumphant, and the many misunderstandings as to the nature of gas (or as it was termed "inflammable air") which they had to fight and dispel. A casual remark of one of the witnesses for the Commission of that date also enables us to realize how imperfect the system of lighting the Streets must have been before the introduction of Gaslighting. The early gas flame burners are stated by this witness to give 3 candle-power...... not a very powerful illuminant judged by modern standards! But what are we to think of the Old Parish Oil Lamps, 18 of which are stated to have been equivalent to the one gas burner, and when it is further stated that they were spaced 30 to 40 feet apart it becomes evident that the illumination of the Streets in those days could scarcely be termed more than a modified form of darkness.

In future articles the development of street-lighting will be traced yet further, and we shall see how, from the defective systems of the past, were ultimately developed the vastly improved conditions of illumination of to-day.

Co-operation in Researches on Photometry.

In this number we reproduce in abstract a paper on Heterochromatic photometry presented by Mr. P. S. Millar at the Third Annual Convention of the Illuminating Engineering Society held last September in the United States. Anyone who has had experience of this subject will bear out Mr. Millar's remarks on the mystifying nature of the many complex phenomena, physical and physiological, which workers in this field have to bear in mind. Mr. Millar will also receive the sympathy of engineers in his desire to obtain fuller information as to how far such phenomena affect practical measurements of illumination. There have been many more or less able researches published on the scientific aspect of the subject, but now that illuminants differing so widely in colour as the incandescent mantle, the flame arc, the Mercury Vapour lamp, &c., are being introduced, it is certainly time to form some better idea as to the practical importance of these effects. We

also appreciate the author's advocacy of co-operation between engineers and physiologists on such questions, and the concerted action of different laboratories. As he very rightly says, such problems are too big to be dealt with authoritatively and exhaustively by any single man. A similar conclusion was stated by Mr. J. S. Dow at the end of his recent paper on the Flicker Photometer, before the Physical Society.

The need for co-operation between the physiologists and engineers on photometrical questions is becoming very keenly felt, but perhaps the other point mentioned by Mr. Millar, namely, concerted action by different laboratories, is at least equally important. It seems only reasonable to conclude that an expert who is associated with one laboratory, and who naturally comes to be specially familiar with certain methods of testing or varieties of instruments, can hardly avoid some tendency towards bias in his decisions, and in the interpretation of his experimental results which may be in themselves perfectly correct. In addition many experts in photometry are themselves the inventors or makers of certain forms of apparatus; this, in turn, may be responsible for some degree of prejudice.

In passing we may add that this desire for fuller confirmation of one's own results by the experiments of others, and appreciation of the necessary limitations of the efforts of a single individual, are characteristic of those who do the best work and possess the true scientific spirit. The man who, in describing his own experiments or apparatus, habitually ignores or underestimates the work of others can only hope to achieve very limited success indeed.

'Glare, its Causes and Effects.'

As announced in our last issue a discussion on the above subject will be opened by Dr. J. Herbert Parsons, F.R.C.S., at the next meeting of the Illuminating Engineering Society, and we hope that members will make every effort to be present on this important occasion. The whole question of Intrinsic Brilliancy and Glare has an exceptional interest for those connected with all branches of illumination, and applies, to some extent, to all systems of lighting. It is therefore one with which the Illuminating Engineering Society should be particularly fitted to deal.

On page 11 in this number will be found a list of queries which has been prepared with the object of collecting information on points of special interest, and suggesting some lines of profitable inquiry. We think that a glance over this series of questions will dispel any idea that this subject will be soon thrashed out. The difficulty would rather be the impossibility of doing justice to such a wide subject in a single meeting, and it may possibly be found desirable to extend the discussion to another evening; even so, we can only hope to initiate enquiries into many specially debatable points on which our present information is very meagre.

Many of these queries may be considered strictly scientific and technical in their scope, and depend for their solution on specialized knowledge such as physiologists and ophthalmic experts can supply. On the other hand it will also be recognized that the subject is one with immediate practical bearings, and one in which the general public is closely interested in daily life.

Even though the Society finds itself unable to frame precise answers to many of these queries at the present moment, we shall be able to originate investigations which will be instrumental in solving many of them in the near future.

We hope that, when we come to review the progress of the past year, we shall be able to look back on much useful work in this direction.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 7), continues his description of the Trotter Universal Photometer of Messrs. Everett, Edgcumbe & Co., making special reference to the nature of the screens employed. He refers to the causes of "ANGLE-ERRORS," and GLARE, and describes types of surfaces by which these errors can be reduced to a minimum, of say 1 to 2 per cent. In addition he draws attention to the fact that the direction from which the observer looks at the photometric screen is of some consequence, and indicates the most favourable position for taking readings. He then proceeds to describe the results of some further experimental investigations on reflection, and gives some polar curves of light-distribution which illustrate the qualities of different surfaces.

On p. 11 will be found a notice of the next meeting of the Illuminating Engineering Society on Jan. 11th, 1910, at which a discussion on the subject of "GLARE, ITS CAUSES AND EFFECTS" is to be opened by Dr. J. Herbert Parsons, F.R.C.S. To this is added a series of queries on which information is specially wanted and which may serve to suggest some lines of profitable research.

A Correspondent on p. 13 contributes some notes on the HISTORY OF THE TALLOW CHANDLERS. He shows how the Tallow Chandlers, when they came to their own, acted in a precisely similar manner to the Wax Chandlers in the previous century ; that is to say they instituted rigorous and beneficial tests for the improvement of the quality of the goods manufactured but eventually misused the power they possessed and endeavoured to throttle the introduction of newer improved forms of illumination by oil, &c.

This is followed by an account of the DEVELOPMENT OF THE GAS, LIGHT & COKE Co., in 1809, and the early progress of gaslighting. Reference is made to an old volume containing the evidence of some witnesses before the Commission at that date which shows how many were the misconceptions regarding the nature of gas distribution which had to be met. It is also made clear how primitive were the arrangements for streetlighting previous to the introduction of gas. Thus it is stated that 18 of old parish oil lamps were only equivalent to one gas-burner, and such lamps were spaced 30 to 40 ft. apart. The resulting illumination must have been very dim.

An article by **Professor Bermbach** (p. 19) deals with the CONTA LAMP, a form of arc lamp recently introduced by the Regina Arclamp Co., which is equipped with what is claimed to be a very simple form of regulation. It is also stated that the arrangement gives rise to much less irregularities in the current consumption of the lamp, and this is substantiated by diagrams showing the fluctuations in the case of both Conta and other forms of arc-lamps.

On p. 25 will be found an account of a lecture delivered by **Mr. Jacques Abady** before the London and Southern Junior Gas Association dealing with the FUNDAMENTAL LAWS OF PHOTOMETRY, &C. The lecturer summarises these laws and points out the conditions necessary in order that they may be rigidly applied to photometric measurements. He also insists on the desirability of avoiding as far as possible empiricism in measurements of this kind. Finally he describes a form of instrument recently devised by himself in which the illumination is adjusted by altering the exposed area of a uniformly illuminated matt white surface.

This is followed by an abstract of a paper recently read at the Third Annual Convention of the Illuminating Engineering Society in the United States by **Mr. P. S. Millar** on "THE PROBLEM OF HETEROCHROMATIC PHOTO-

METRY." Mr. Millar briefly mentions a few of the physiological effects to be encountered in work of this kind, and describes some experiments designed to test their influence in practical work. These tests show that although fair accuracy can be obtained in the case of the comparison of sources only slightly differing in colour (such as tungsten and carbon filament lamps), more serious errors are possible when such sources as the mercury vapour lamp and the magnetite arc are studied. In conclusion the author insists that the problem is too big for any one man to deal with and advocates concerted researches between different experts and various laboratories.

On p. 31 will be found another article dealing with photometrical matters in which the DETERMINATION OF MEAN SPHERICAL CANDLE-POWER is discussed. In this the author gives a brief summary of the chief methods of laboratory testing in this field, and of shortening the calculations involved in determining the M. Sph. C.P. from experimental results.

On p. 25 will be found the conclusion of the recent paper before the Institution of Gas Engineers, by **Mr. C. Forshaw** dealing with the INCANDESCENT ILLUMINATING EFFICIENCIES OF HYDROGEN AND CARBON MONOXIDE. In this he describes some additional experiments, involving the use of solid cones within the flame, and their effect on the results obtained from the above two gases; finally he summarises the conclusions of the whole paper.

A correspondent deals on p. 42 with ACETYLENE LAMPS IN MINES, pointing out their chief advantages in this connection and describing a number of the best-known French types of lamps.

Mr. R. H. Stephens deals with OIL FOR LIGHTHOUSE ILLUMINATION. He points out the advance made in oil-lighting by the use of an incandescent mantle and describes the Kitson system of incandescent oil lighting. Special reference is made to the value of good "penetrating power" for lighthouse work.

Mr. H. Thurston Owens (p. 51) summarises the PROGRESS OF ILLUMINATING ENGINEERING IN EUROPE. He refers to the starting of *The Illuminating Engineer* and the Illuminating Engineering Society in this country and also gives his impressions on the chief respects in which outside lighting in Europe differs from American practice. Special reference is made to the development of high pressure gas and the flame arclamp for streetlighting, which have for some time been accepted facts in Europe, but have only recently made much headway in the United States.

Among other articles we may mention that on p. 53 in which reference is made to a recent publication of **Dr. L. Bloch** on INTERIOR LIGHTING BY ELECTRICITY. The question is considered how best to apply the metallic filament lamps to existing fittings in cases where æsthetic considerations are of paramount importance. **Mr. H. N. Clark** recently delivered a paper dealing with the question of FREE MAINTENANCE of Incandescent Burners for consumers; this is abstracted on p. 56.

Mention may also be made of the account of the LIGHTING of several SCHOOLS in New Jersey by Holophane fixtures (p. 57). In this case the main object was to avoid streakiness and glare and to produce uniform illumination. A subsequent note refers to some experiments of **Dr. Ubbelohde** on the viscosity of illuminating oil and its effect on the drawing power of the wick (and therefore also on the illuminating power of oil-lamps). On p. 61 will also be found a short account of a recent discussion in the United States dealing with PHYSIOLOGICAL ASPECTS OF ILLUMINATION.

The Correspondence Columns this month contain letters from **Professor O. Lummer** and **Mr. A. P. Trotter** regarding the LUMMER BRODHUN PHOTOMETER.

At the end of the number will be found the usual REVIEW of the TECHNICAL PRESS (p. 69) and several pages devoted to novelties under the heading of Trade Notes (p. 63).

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p.* 802, *Vol. II.*)

The Screens.—Messrs. Everett, Edgcumbe & Co. have substituted for the Bristol board, which I have used for so many years, a white celluloid composition. So long as this is thick enough to ensure that it will not warp, it seems to be an excellent material. The character of the surface of the movable screen is of no consequence so long as it does not change in shape,

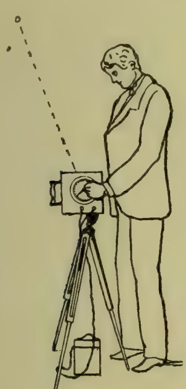


Fig. 101.—Worst position.

seeing that the scale is graduated by experiment, but the surface of the perforated screen is of great importance.

Two kinds of angle errors may arise from a perforated screen of an unsuitable surface. If it is at all shiny, and the light from a lamp falls upon it at an angle of incidence equal and opposite to the angle from which the screen is observed, the glare will add to the apparent brightness, and the photometer will read too high. On the other hand, if the illumination received by the perforated screen falls on it at a considerable angle, if the surface is not suitable, the cosine law will not hold good. I find that an excellent surface can be obtained on this white celluloid by finely powdered pumice rubbed on with a ground glass rubber and plenty of water.

Mr. Preston S. Millar* discusses what he calls the test-plate with great minuteness and considers that there is no material which meets all his exacting requirements. Unfortunately he gives no experimental results showing the departure from the cosine law.

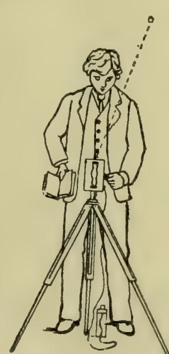


Fig. 102.—Best position.

The reprint of Mr. Millar's paper referred to on p. 658 contains an almost illegible diagram purporting to show "errors due to improper location of the test plate." One of the curves appears to resemble the curves given in Fig. 78, p. 440, of a preceding article of this series. Discussing as he does

* Loc. cit.

many different kinds of illumination photometers impartially and thoughtfully, he considers that the test plate should not be viewed from above "because it would necessitate interference with light which would otherwise fall upon the test plate. It follows therefore that the correct method is to consider transmitted light from a point directly beneath the test plate....This means that all instrument parts, as well as the observer, must be beneath or behind the test plate. This is possible only when transmitted light instead of reflected light is measured." It is true that in some illumination photometers, such as that of Dr. Martens, the test plate is placed in an unfortunate position, but in the course of a rather extensive practical use

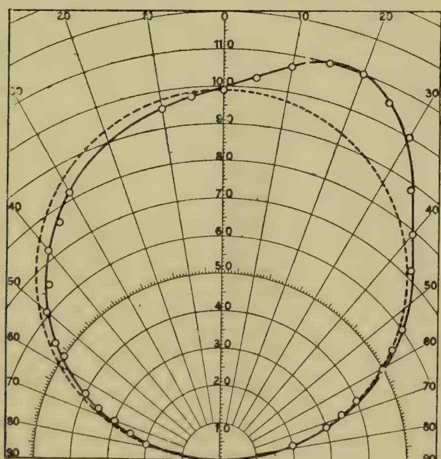


FIG. 103.

of my photometers, I can remember only one occasion on which I was inconvenienced by my own shadow. This was in the South Kensington Museum. In one court I was surrounded by ten arc lamps. I stood a short pencil upright on the screen and counted the radial shadows. I walked round and noticed in what positions of my body any of these shadows disappeared, and thus found a direction in which all ten were present.

Angle Errors.—From my earliest experiments with Sir W. Preece in 1883 and throughout my work in 1891–2 I always measured illumination on a horizontal screen. There has been much discussion about this practice, and the matter will be examined in a future section. Meanwhile it is sufficient to admit that on a horizontal plane at some distance from a lamp, and therefore with a considerable angle of incidence, the illumination is much more feeble than if the plane were tilted to face the lamp. Two kinds of error may arise, one due to a slight inaccuracy in levelling, and the other due to the nature of the material of which the screen is formed. The former may be dismissed for the present.

It is obvious that if the surface of the screen is not perfectly matt, there will be some specular or regular reflection when the angle of incidence is equal to the angle of view, but it has been suggested also that with most substances there is a wide departure from Lambert's cosine law at large angles of incidence. This allegation is not well expressed, for the cosine law is a question of illumination received, not of light emitted or of apparent brilliance. The emission of light from matt surfaces, or the law of diffused reflection has been discussed by Bouguer and other writers, and I hope soon to contribute something to the knowledge of this subject. In the present case the matter is somewhat simplified by the fixity of the angle of view or angle of emission from the perforated screen.

In the course of my investigations of the law of diffused reflection I have not found with such a material, for example, as white celluloid, either well matted or half glazed, that there was any appreciable error at large angles of incidence. There are several experimental difficulties in making the measurements with smaller errors than 1 or 2 per cent, and within such limits no systematic error was found. On the other hand I have examined a celluloid screen which had been in practical use for some months, and had been repeatedly cleaned. It might have been better if it had been allowed to become dirty. That could have

been taken into account by a simple correcting factor found by the usual check measurement. I found that under certain circumstances not likely to occur often in practice, the error due to the partially glazed surface might amount to 27 per cent. But even with this obviously imperfect screen the maximum error might be reduced to about 5 per cent by proper placing of the instrument.

Error Due to Glare.—Appreciable angle error due to want of perfect mattness, or in other words to a slight glaze on the surface of the screen, can only occur when the light falls at an angle approximately equal to the angle at which the screen is viewed—in this case, about 20°. Fig. 101 shows the worst position in which a worker can place himself and the photometer with respect to the light. If the photometer is turned through a right angle, and the light falls sideways, the error will be a minimum.

Measurement of Angle Errors.—The screen of a photometer may be tested for angle error by mounting a suitable lamp on a radial arm. The axis on which it turns must pass exactly through the slot of the screen. If the screen is viewed in the plane in which the radial lamp revolves, the view will be blocked by the lamp, or the observer's head will intervene between the lamp and the screen when the light from it falls at 20° incidence or thereabouts. If the screen is viewed crosswise with this plane, a complete semicircle of reading can be obtained. In testing such screens I have used a specially constructed apparatus, not depending on a moving screen with a cam and a calibrated scale, but on the motion of a lamp on an ordinary photometer bar. The light from this lamp fell on a fixed inner or back screen, visible through the slot in the screen under test. The illumination on the back screen was a measure of the brightness of the perforated screen when a photometric balance was effected.

The matter will be perhaps better understood if the case of the badly-glazed screen, to which reference has been made, is taken first. Fig. 103 is a polar diagram of the observations. The line of view was in the plane in which the lamp revolved, this being the worst position. The angles represent angles of incidence of the light from the radial lamp, and the radii are observed brightness, when viewed at 20°. The apparatus was adjusted with the intention of obtaining an illumination of 100 as measured on the photometer bar; when the incidence was 0°, the actual reading was 99, but the general direction of the curve suggests that this was about 1 per cent too low. For the present purpose of considering the departures from the cosine law as instrumental errors, the brightness at 0° may be taken as 99, and the depar-

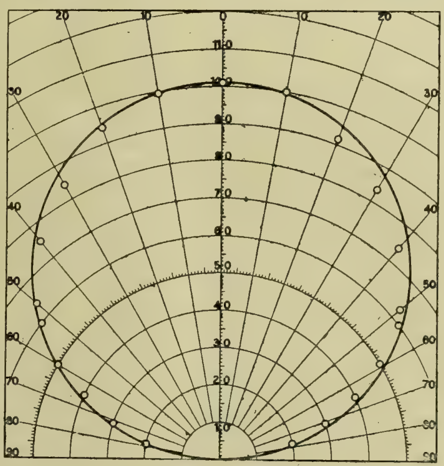


FIG. 104.

tures may be taken as excess or defect. On another occasion I propose to discuss the law of diffused reflection in a different manner. Since the object of the tests of this glazed screen was only to obtain the general shape of the curve, a single observation only was made at each angular position; errors of observation amounting to about one per cent are present.

Assuming for the present purpose that 99 is the true value at 0° incidence, the dotted circle (Fig. 103) represents the cosine law; there is a positive error or excess of 16 per cent. at 20° when the reflection due to the glaze is a maximum as in Fig. 101. Between 45° and 60° on the same side, which may be called the front side, since the

lamp is in front of the observer, there was a fairly constant excess error. At 20° on the other side the view was blocked by the lamp. From 30° to 70° on the back side there was a deficiency of about 0·04 foot-candle. At 30° this error is equivalent to about 5 per cent, and at 70°, the deficiency being about the same, was equivalent to nearly 22 per cent.

Fig. 104 is a similar diagram of the errors of this badly glazed screen in the best position, that is, viewed at right angles to the plane in which the lamp revolved (Fig. 102). The errors of observation were a little larger, but an oval or ellipsoid such as has been described by Bouguer and others would represent the curve.

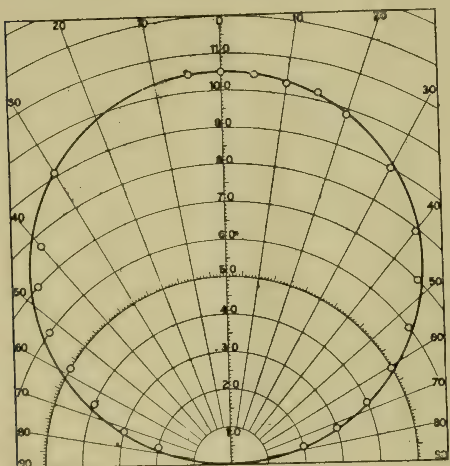


Fig. 105.

The errors are all in defect if the observation at 0° incidence is assumed to be correct. At 40° it is about 0·02 foot-candle, or 5 per cent.

Fig. 105 is a similar diagram of a well-matted celluloid screen viewed in the worst position. The divergencies from the cosine law are so small that they cannot be clearly shown on a diagram, but they can be shown better numerically.

The first column of the following table gives the angles, θ. From 78° to 40° the lamp on the photometer bar was set to a round number, and the angle of the radial lamp was adjusted to give a balance. From 40° to 0° the angle was adjusted to a round number, and the lamp on the bar was adjusted to obtain the balance. The readings on the bar give E the observed brightness. These readings are set out in the second column. For the present purpose the reading at 0° incidence (namely 105) is regarded as correct.

	θ	E.	105 cos θ	Diff. %
Back.	77	20	23·6	—18
	72	30	32·4	—8
	65½	40	43·6	—9
	58½	50	55	—10
	52½	60	64	—6·6
	46½	70	72·4	—3·4
	40	77·3	80·5	—4·2
	30	91	91	0
	20	blocked		
	10			
	5	105	104·5	+0·5
	0	105	105	0
Front.	5	104·5	104·5	0
	10	103	103·4	—0·4
	15	102	101·4	+0·6
	20	98·5	98·8	—0·4
	30	90	91	—1·1
	40	79·5	80·5	—1·3
	47	70	71·6	—1·24
	54	60	61·8	—3·3
	60½	50	51·8	—3·6
	67	40	41·0	—2·5
	72	30	32·4	—8
	78	20	21·8	—9

The first difference of 18 per cent seems to be serious, but it would be accounted for by a difference of angle of 2°. The experimental difficulties at large angles of incidence are considerable. The graphical plotting as in Fig. 105 is quite unsuitable for showing the departure from the cosine law at large angles. The departure from the cosine law on the assumption that there is no error at 0° incidence is, however, negligible for all "front" angles down to about 70°.

With a well-matted celluloid screen in the best position (see Fig. 102) the systematic errors from 70° on one side to 70° on the other do not exceed more than about 3 per cent., or the ordinary errors of observation for outdoor industrial photometry.

(To be continued.)

The Illuminating Engineering Society.

(Founded in London, 1909.)

Glare, its Causes and Effects.

The **Next Meeting** of the **Illuminating Engineering Society** (Founded in London, 1909) will be held on **Tuesday, January 11th, 1910, at 8 p.m.**, at the house of the Royal Society of Arts (Adelphi, London), when a discussion on the subject of '**Glare, its Causes and Effects**,' will be opened by Dr. J. Herbert Parsons, F.R.C.S.

In order to make the discussion as complete as possible it is hoped that foreign members, and others who are unable to be present, will send in written contributions to the discussion to the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.) previous to the meeting. Members are also requested to draw the attention of friends likely to be interested in the matter to this discussion and to invite suggestions from them.

The accompanying list of queries* (which is only of a suggestive character and is not intended to be exhaustive), has been prepared in order to indicate a few points on which further data are desirable and on which the collection of the views of different authorities is specially to be desired. Naturally further comments on matters of interest in this connexion which are not included in the list will also be welcomed. Practical demonstrations, the exhibition of lantern-slides illustrating the results of glare and methods of avoiding it, and the presentation of the results of special enquiries or experiments undertaken in response to these queries will be particularly appreciated.

Members and others desiring to participate in the discussion are requested to send in their names to the Hon. Secretary previous to the meeting.

List of Queries :—

1. What exactly constitutes a "glaring" system of illumination ?

2. Evidence is needed of instances in which undue brilliancy of injudiciously placed sources of light has been unquestionably prejudicial to eyesight. Suggestions for the collection of data regarding eyesight and health and conditions of illumination enjoyed by school children, &c.

3. Is it desirable to recommend that sources of a brilliancy higher than a certain limiting value should never be used unscreened in interiors ? Or that such sources should always be placed a certain minimum distance from the ground ?

4. What is the maximum intrinsic brilliancy on the part of an illuminant which can be considered physiologically harmless, under ordinary conditions ? To what extent is the glaring effect of bright lights dependent on the distance of the eye, on "brightness per unit area," and on the area and total amount of light radiated by a source ? In what manner is the desirable intrinsic brilliancy of an illuminant governed by the brightness of surroundings and by the area over which the glare is distributed ?

To what degree is the sharpness of the shadows cast by concentrated sources of great brilliancy responsible for glare ? Is the effect of glare rendered more acute by variations in the intensity of an unsteady source of light ?

5. Is there any reliable and simple physiological test by which it can be readily ascertained whether an existing system of illumination is open to objection on account of glare ? Could the opening and closing of the pupil-aperture be so used ?

6. What instruments are available for measuring in a simple manner the intrinsic brilliancy of any luminous object ? And what accuracy may be expected in such measurements ?

7. Is excess of light of all colours equally harmful ? To what extent are the prejudicial effects of incautious exposure to brilliant sources of light due to ultra-violet rays ?

* Members may obtain additional copies of this list of queries on application to the Hon. Secretary, Mr. L. Gaster, 32, Victoria Street, London, S.W.

8. Is the intrinsic brilliancy of some sources used in the streets too high? And would a restriction of the existing brightness prove beneficial from the point of view of traffic, &c.? Suggestions regarding the avoidance of glare from the headlights of vehicles, &c.

9. What is the best intrinsic brilliancy for illuminated signs and advertisements? And how is this affected by the distance away from which they are to be viewed?

10. Should any recommendations as to the limiting brightness of illuminants, and illuminated surfaces, such as shades &c., in interiors, be made from the artistic standpoint?

11. Actual examples of practical cases (*e.g.*, well-known buildings, shop-lightings &c.) in which insufficient attention has been paid to securing absence of glare, or specially successful means adopted to avoid it.

Forthcoming Lectures on Light and Illumination at the Royal Institution.

It is very gratifying to observe that the subjects of light and illumination will be dealt with exceptionally fully in the newly issued programme of the Royal Institution for 1910.

We notice that Professor S. P. Thompson, D.Sc., F.R.S., the first President of the Illuminating Engineering Society, will very appropriately deliver a series of three lectures on Thursdays, February 17th, 24th, and March 3rd at 3 o'clock on "Illumination, Natural and Artificial."

Again, the series of Christmas Lectures to be delivered by Mr. W. Duddell, F.R.S., deal with Modern Electricity, and the last of the series is to cover the subject of Electric Lighting. These lectures will take place at 3 o'clock on December 28th, December 30th, January 1st, 4th, 6th, and 8th respectively.

Among the other items we also note that Prof. Sir J. J. Thompson, M.A., D.Sc., F.R.S., &c., is to lecture on "Electric Waves and the Electromagnetic Theory of Light," on Saturdays, February 12th, 19th, and 26th, March 5th, 12th, and 19th, at 3 o'clock.

Dr. Ludwig Mond.

It is with deep regret that we record the death of Dr. L. Mond on December 11th, 1909. Dr. Mond was widely known for his distinguished work in many departments of chemical science, and as the inventor of many important industrial processes. But we feel that his name has a special claim to remembrance as one who did much to stimulate the spirit of scientific research in this country, and as the founder of the Davy-Faraday Laboratory.

ERRATA.

We regret to note that, owing to a misprint, the qualifications of Mr. L. A. Stokes, one of the Vice-Presidents of the Illuminating Engineering Society, were incorrectly stated in the list of members published in our November number (p. 830). The correct description should be:—

V.P. Stokes, L. A., *F.R.I.B.A.*, Past Vice-President of the Royal Institute of British Architects, 2, Great Smith Street, London, S.W.

Also:—For "C.M. Libesney, A., &c." (p. 834), read "C.M. Libesny, A., &c."

Some Notes on the History of the Tallow Chandlers.

Their Influence on the Standardisation of Lighting Apparatus and on the Restriction of Adulteration.

By an Engineering Correspondent.

In a recent number of this journal some account was given of the early proceedings of the Waxchandlers' Company in the 14th century (*Illuminating Engineer*, November, 1909, p. 734). We saw how the Wax Chandlers were responsible for the rigorous examination and preservation of the purity of wax candles according to a detailed specification and how insistence was placed upon the guarantee-value of a mark on each candle coming up to the required standard.

But we also saw how the privileges accorded to the wax chandlers led to abuses in other directions as soon as they began to experience the competition of other systems of illumination. Let us now proceed to trace some of the experiences of the tallow chandlers, who, in the times mentioned in the last article, were struggling against a monopoly, but who in their turn were eventually successful, and likewise aimed at the standardisation of lighting apparatus, only to pursue in the end equally vigorous methods of obstruction against new rival systems of lighting.

When eventually it was discovered that the wax candle was no longer up-to-date, and in addition not nearly so applicable for general use as the tallow variety, and when, too, the relative costliness of tallow and wax was found to be approximately 1 : 15, the tallow candles forced their way to the front as the chief illuminants, and the makers of tallow—the Tallow Chandlers—in turn became the masters who fixed the price and quality of the chief illuminant available for street lighting.

The rivalry and the gradual superseding of wax by tallow can be seen from the very fact that the tallow chandlers combined to form a regular organization long before they had any licence or charter or established commercial fellowship. Indeed, we receive the first intelligence of them as early as 1426, when they were associated under the style of "The Master and Wardens of the Mistery or Craft of Tallow Chandlers, in letters patent of Henry VI. for the search and destruction of all bad or adultered oils." They were acknowledged as a body by the giving of a grant of Arms and Crest to "John Priour, John Thirloe, William Blackman and Richard Greenkroft, Wardens, and to other notable men of the fellowship and occupation of Tallow Chandlers of London, Freemen, and to their Successors for ever, by John Smart, alias Garter, under his hand and Seal of his Office bearing date Sept. 24, Anno. Dom. 1456, 35 Hen. vi." The motto was: "Delight in God, and he shall give thee thy Heart's Desire." The supporters were added and arms and crest allowed in 1602, upon an application to William Camden, Clarencieux, with the motto: Quae arguuntur, à Lumine manifestantur.

It is interesting to note that from this moment the tallow chandlers were authorised to make, constitute, and put in force among themselves, rules and good ordinances for the separate conduct of their own trade. Since, therefore, they were in possession of the monopoly of the only available illuminant, they were also virtual controllers of street-illumination, especially when the system of private lighting prevailed.

At last, in 1462, they obtained their first charter by Edward IV. It was addressed "to our beloved and faithful subjects the Freemen of the Mystery and Art of Talough Chaundelers of our

City of London," and this charter was confirmed by Henry VII., Edward VI., Philip and Mary, Elizabeth, James I., Charles II., and James II.

I have dwelt at length on this ancient history of the Tallow Chandlers for a very good reason. For they always refer, as we will see afterwards, to their beginnings, as being the only body which is entitled to state an "expert opinion" on matters concerning the lighting of the streets. And it may be added in this connexion that the Tallow Chandlers, from the 3rd year of Hen. VIII. onwards, were appointed to "search" oils—the other illuminants coming into use. They had also the power to destroy such as were "mingled and corrupt." This prohibition of adulteration of oil for lighting purposes goes back—unless I am mistaken—to that proclamation forbidding the adulteration of oil used for food: 5 Richard II. A.D. 1382, Letter-Book H, fol. cxxxix. (Norman-French).

"Be it proclaimed, that no one shall sell the best oil of Lusshebone [Lisbon], used for food, at a higher rate than 16d. per gallon, and that, by sealed measure. And that no person shall mix any oil of Cyvylle [Seville] with oil of Lusshebone, on pain of forfeiture of the oil so mixed."

The Tallow Chandlers did not fail to exploit this privilege in the case of oil for lighting purposes and candles, and also destroyed much oil that might have been put to good use but was not of the specified quality. At first no fee was granted to the execution, so—according to Stow—it was neglected. But in Queen Elizabeth's reign, when abuses and deceits daily multiplied in this trade, they agreed "that Roger Tyler, one of the Wardens, and in good credit among them, as well as for his honest dealing as for his skill in this his trade, should sue in name of the whole Company to her Majesty for a new grant to search and destroy corrupt wares, &c." And hereupon they petitioned the Queen: "For reformation whereof, the Master and Wardens of Tallow Chandlers of London, who did retail these things and finding daily these deceits, were moved in conscience to procure redress: Did most humbly beseech the Queen's Majesty to grant them authority to have the perusing of these things, with officers for the reforming of these deceits, and for the seeing these things to be good and perfect from henceforth." The Queen's Letters Patent to this Company bore date at Westminster, the 15th of April, in the 19th year of her reign, naming, appointing, and authorising "the Master, Wardens, and Commonalty of the Art and Mystery of Tallow Chandlers, of London and their Successors and Deputies, to be Searchers, Examiners, Viewers, and Triers, of all Sope, Vinegar, Butter, Hops and Oils." And though the Lord Mayor and Court of Aldermen, October, 1583, resisted the execution of this patent, the Tallow Chandlers retained it.

As regards candles, they did not shrink from using all kinds of weapons in order to preserve their rights. In the reign of King Edward VI., anno 1551, they refused to sell any candles, by an universal consent, simply and solely because the City set up too low a price "upon their commalities." And it came to such a pass—according to Stow—that orders were taken by the King and Council, commanding them to sell their candles, and some of them were sent to prison (*sic !*).

Their whole power was also merged in a struggle against the so-called "public convex light." According to Macaulay, the state of things was as follows:—

"It ought to be noticed that in the last year of the reign of Charles II. began a great change in the police of London, a change which has perhaps added as much to the happiness of the body of the people as revolutions of much greater fame.

"An ingenious projector named Edward Heming obtained letters patent conveying to him for a term of years the exclusive right of lighting up London. He undertook for a moderate consideration to place a light before every tenth door on moonless nights, from Michaelmas to Lady Day, and from 6 to 12 o'clock. Those who now see the capital all the year round

from dusk to dawn, blazing with a splendour beside which the illuminations for la Hague and Blenheim would have looked pale, may perhaps smile to think of Heming's lanterns, which glimmered feebly before one house in ten during a small part of one night in three. But such was not the feeling of his contemporaries. His scheme was enthusiastically applauded—and furiously attacked. The friends of improvement extolled him as the greatest of all the benefactors of his city. What, they ask, were the boasted inventions of Archimedes when compared with the achievements of the man who had turned the nocturnal shades into noonday? In spite of these eloquent eulogies the cause of darkness was not left undefended. There were fools in that age who opposed the introduction of what was called the new light as strenuously as fools in our age have opposed the introduction of vaccination and railroads......"

So far Macaulay. Those he terms "fools" were for the most part the Tallow Chandlers who saw their interests and their ancient privileges and customs threatened. When in 1694 a licence was granted by the corporation to certain persons "concerned and interested in glass-lights, commonly called and known by the name of convex lights" for the sole supply of the public lights in all public places in the city, for twenty-one years, the Tallow Chandlers protested most vigorously against this new system. In the following I give for the first time a reproduction of this protest. This historical monument of a last position is couched in the following denunciatory terms:

REASONS humbly offered to the Right Honorable the | Lord Mayor, Aldermen, and Commons, of the City of | London, in Common Council assembled, by the Company of | Tallow-Chandlers of the same City, against setting up and | establishing the Lamp-Lights of any sort in this City, as varying from the antient Custom.

THAT this Company have been Incorporated about 230 Years, and are now become a numerous | Body; several of whom have been called to, and served in the greatest Places of Trust and Honour | of this City, and have always assisted as well in Purse as Person to add to its Grandure, and to the | support of the present Government.

That this Company, with the whole City, being restored to their antient Privileges and Customs | thought themselves safe from any other Invasion of their Laws, one of which is an Act of Common | Council, made the 3 of October, 1599, whereby every Housholder from the First of *October* to the First of *March* in every year for ever, should cause a substantial Lanthorn and a Candle of Eight in the Pound to be hangd without their Doors.

That notwithstanding the said Act (still in force) certain untrue men, who are not capable of serving any office in any Company, nor Office of Trust within this City, neither chargable towards the | support of the Grandure and Government of the same, have set up, and do continue in the Streets of this City and Liberties thereof, a great number of *Convex-Lamps* and other *Lucidaries*, in opposition to, and derogation of, the said Act, and to the manifest Injury of this and other Companies, in their lawful Trades.

That the aforesaid *Lamps* or *Lucidaries* are merely Novel, and should they be encouraged they will cause many more such intrudings upon other Arts and Mysteries, whereby the Labour and Industry of many Thousands may be lost, and their Families impoverish'd.

That the setting up, and use of the said *Lamps*, within the City and Liberties, for the time past have been, and for the future will be a great Prejudice, if these New Lights obtain the countenance of a Common Council.

First, To this Company, in taking away the Use of their lawful Trade, to which they have serv'd and taken many Apprentices, and made suitable provisions for carrying on their Trades, for the subsistence of themselves and Families; and that if the | continuance of these Lamps be suffered, they will hinder the making and selling of Seventeen Dozen of Candles to every Lamp |

set up and used in this City and Liberties in every Year, and so much will be taken away from the maintenance of the *Tallow-Chandlers* | and Families, and the support of their lawful and useful Trade.

And altho great annual Rents, and other Considerations may be offered to this City, by the Partners of the several New | Lights, (and as they pretend) towards payment of the Orphans, yet nevertheless it is hoped, that not any of those New Lights | will be Established for the sake of such Rents; and at the same time, by so doing, deprive the *Tallow-Chandlers*, and other | Trades in the Profits thereof, to a far greater value than the Profits of the Lamps can accrue unto the *Orphans*.

And to other Trades, as the *Horners* in making of Leaves for Lanthorns, for burning Candles in; *Tinmen*, and *Spinners* of | *Cotton*, wherof the Twentieth part is not, nor cannot be used in Lamps, which is, and must be in Candles; and must necessarily deprive many hundreds of Persons, (that live solely by those Trades), of their Maintenance and Livelyhood.

Secondly, That all Monopolies in all Ages have been esteemed Destructive, Oppressive, and against the Rights of the Subjects, and contrary to *Magna Charta*, and many other Statutes, and to the Common Law. And it was solemnly adjudged in | the 44 Eliz. in *Cook's* II. Report, in the case of Monopolies, and many other cases. The same was so declared by Proclamation in the I. of King *James* I. and by a Statute made in the 21 year of his Reign, *Cap.* 3 yet under a Proviso to grant | Letters Patents to the first inventers of the New Manufactures for 14 years, not contrary to Law, nor hurtful to the People, as may | appear by the Paper of Reasons now in Print, and lately offered by this City to the Parliament, against their passing the Bill | for granting a further Term to the Partners concerned in the *Convex Lights*, which Bill being put to the Question it passed in the | Negative, as may appear by the Votes of that Honourable House on Friday the 30th of *December*, 1692.

It is humbly hoped, that Projects so pernicious to the publik Good of the Kingdom, and the private and lawful Trade | of many Thousands of Their Majesties Subjects, who as the Law stands, have as great a Right as any other of | Their Majesties Subjects have to their Trades, and the lawful Use and Advantages thereof, will not find or receive any encouragement from this City. And for that the Parliament would not give any encouragement to the CONVEX-LIGHTS (as is humbly conceiv'd) in tenderness and regard to the Privileges and Customs of this City, so this Company a part | of, and subject to, the Corporation of this City, may justly hope, they will not do any act to the prejudice of this Company, in relation to their said Trade.

But that the Act of COMMON COUNCIL for enlightning the Streets of this City with Candles in Lanthorns may be strictly | observed, or that this Honorable Court will be pleased to make another Act, for the more strict and regular Observance of the Duty of Lighting the Streets of this City and Liberties with Tallow Candles in Lanthorns, which will be cheaper to the Inhabitants than any sort of Lamps.

And the tallow chandlers seem to have gained the victory. For when the lease had expired we hear no more of the glass lights or convex lights; and "every house-keeper whose house fronts any street or lane and is of the rent of 10 pounds, and every person having the charge of a public building, are each required and obliged in every dark night, from the twenty-ninth of September until the twenty-fifth day of March, to hang out one or more lanthorn or lanthorns, *with sufficient cotton-wick candles lighted therein*, and to continue the same burning in every such dark night, from the hour of six until the hour of eleven of the same night,"

The last occasion on which the Tallow Chandler Company exercised their ancient right and "destroyed defected candles" was in 1709. But the times were out of joint for such old customs. The injured tallow chandlers whose goods they destroyed took proceedings against the Company for damages—and won the case. Dr. B. Sch.

The Development of Gaslighting and the Formation of the Gas Light and Coke Co. at the Commencement of the Last Century.

By the courtesy of the librarian of the London Institution we have had the privilege of perusing an old volume, published in 1809, in which some account is given of the early stages of the formation of the Gas Light and Coke Co. in that year, and which sheds an interesting light on the ideas of the people of that time on illumination. Many of the remarks also enable us to see how incomprehensible to many was the whole conception of the transmission of gas through pipes, and how magnificent appeared pretensions as regards lighting which we should now regard as modest in the extreme.

The first item in this work is an account of the speech of Mr. Van Voorst to a meeting of the proprietors of the Gas Light and Coke Co., held at the City of London Tavern on Thursday, July 6th, 1809. He remarks: "I say that if this company goes to work, we shall become the admiration of the world, and we shall be able to say, what no other nation can, that all our public roads are lighted every night." This, however, was only one of the things to be accomplished, for in his peroration he added, "We shall be able to hurl back this defiance of Russia and her threat of starving us for the want of tallow, tar, pitch, asphaltum, and nearly the whole of her productions." And finally he refers to the opposition encountered by an honourable member, "who starts up and says 'They will hurt my South Sea Fishery!' But what is that to me, a poor gas-light shareholder? I answer, 'Then the poor whales will live in greater peace and grow to their intended size; for it is known that gentlemen complain that they cannot kill the fish as large as formerly!' "

The proposed new system of lighting naturally attracted a considerable amount of attention on the part of the general public. We notice, for example, some humorous verse addressed to Mr. Winsor and entitled 'An Heroic Epistle,' in which his claims are discussed in the conventional satirical style of the time. Thus the poet addresses himself to the "Scholiasts," who had hitherto slaved by the candle's beams, remarking :—

> "Had Winsor's patent lamps to you been known,
> Blazed in your glades, in your Lyceum shone;
> Their lucid nature had your genius hit,
> And Hydrocarbon aided attic wit."

He also pokes fun at Winsor's expectations of the value of gas for heating and lighting greenhouses, drawing a picture of a giant growth of mushrooms, puff-balls, &c., under the influence of the new illuminant which calls to mind H. G. Wells's imaginative efforts in 'The Food of the Gods.' Winsor anticipated that the products of combustion of the patent light stove, "light and caloric, hydrogen, nitrogen, carbonic acid, &c.," might be more powerful in stimulating vegetation than the solar rays under ordinary conditions.

He was, indeed, optimistic in some of his visions of countless applications of his scheme, and seems to have claimed that he cured himself of constitutional asthma by inhaling his own "hydro-carbonic acid gas," and to have invited others afflicted with "morbid lungs" to try the same remedy. On the other hand there were some who drew a very different picture, and seem to have anticipated nothing less than the asphyxiation of the inhabitants of London by the products of combustion of the gas, even in the streets. We have before us a cartoon in which the entire population of a street are breathing with the utmost

difficulty, and inquiring "Why are you funking us with your foul smoake?" We are bound to add that, unless the picture does injustice to the gas lamps of that time, they cannot be considered smokeless.

Equally interesting are the questions put to many of the witnesses before the Committee dealing with the Bill of 1809. Gas is usually referred to as "inflammable air." The question was raised whether gas could take fire spontaneously in the pipes, whether gas issuing from a leak would take fire if a light were applied, whether the gas flowed through the pipes "from its own elasticity" or as the result of force applied to it, and whether it was really possible to transmit gas for miles in this way. One witness had also to reassure the Committee that this particular illuminant gave no sparks, and to explain how it was possible to regulate the flow of gas "by turning a stopper....just like water or beer in a barrel."

The questions addressed to several witnesses on the method of estimating the light from gas flames show that the idea of the measurement of light was not an entirely unfamiliar one. Thus Mr. Accum mentions that he measured the light by Count Rumford's method; he evidently despaired of explaining its nature to Commission, however, for he added, "if I were to speak for about an hour, I could convey some notion of it."

Very interesting, too, are the particulars stated by this witness regarding the new light. He described the gas flame as "A vivid white; a brilliant light"—a description which would hardly be concurred in to-day, with the incandescent mantle at our disposal. When invited to say whether it was "as dazzling as the Argand lamp," he declared that it was "of equal splendour." We get a very vivid idea of the inefficiency of the street lighting in pre-gas days from his statement of the capacity of the average parish oil lamp. There were at this time several newly installed gas lamps in Pall Mall, and each one of these was stated to give as much light as 18 parish lamps! Yet another witness states that these parish lamps, having, according to the above estimate, an intensity of about $\frac{1}{6}$ of a candle-power, were usually 30 ft. to 40 ft. apart. It was also stated that the gas flame and the candle gave an illumination in the proportion of three to one, and the Committee then wanted to know whether this meant that "it will throw a given amount of light three times the distance." The witness said he had not tried that experiment!

A very good point was, however, made by one member of the Committee who had evidently some clear ideas on the subject of the distribution of light for street illumination. What he desired was uniformity, and he asked whether, as a gas flame gave three times the light of a candle, the one gas lamp would give the same illumination at any point as when three candles at given intervals were used.

Finally, we may refer to the evidence of a Mr. Lee, who was cross-examined on his views on the relative intensity of certain lamps in neighbouring localities. He was naturally asked whether he had with him any light by which to judge in making such a comparison between lamps which were in different streets, and therefore not visible at the same time. He admitted that the comparison was made from recollection. But he added, "the habit of looking at those things familiarizes one to them." This, indeed, is a plea which has a strangely familiar ring, even in our own days, when the measurement of light has become such a vastly better known process.

A "Universal" and Simple Form of Self-Regulating Arclamp.

SUMMARY.

After describing several types of arc lamps utilizing inclined carbons and with simple regulating arrangements, the author describes a new lamp in which no complicated regulating apparatus is employed, and in which ordinary round carbons are used. The chief qualities of the lamp are described and reference is made to a number of physical phenomena connected therewith.

By Prof. Bermbach (Cologne).

Attempts have already been made to construct arc lamps, having either inclined or vertical carbons, and utilizing no complicated regulating mechanism. For example, Beck* has recently constructed a lamp of this type. In this lamp the negative electrode is supported, being provided with a projecting rib which rests on a metal support in the form of a conical roller. The movements of the positive and negative electrodes are mutually dependent.

The current enters at the upper end of the positive carbon, flows through this and also through the arc, and then out by means of the metallic support; thus it does not pass down the whole length of the negative carbon, so that the total fall of P.D. in the carbons is reduced. In order to reduce fluctuations of current to a minimum a series resistance composed of a material having a high temperature co-efficient, such as iron, is used; the thin iron wires composing this resistance are inserted in tubes filled with hydrogen, in a somewhat similar manner to the Nernst series resistance.

Mention may also be made of the Janecek lamp† which is constructed by the A.E.G. in Berlin. An iron strip, having teeth at regular intervals along its length, is inserted into and projects from the positive carbon. The lowest tooth rests on a porcelain support slightly above the arc. The temperature of this tooth is gradually raised by conduction and radiation, and tends to continually increase as the positive carbon burns away. Eventually the tooth slips past the support and allows the positive carbon to fall and with it the negative.

Very recently the Regina Company, in Cologne, have also brought out a lamp without mechanism, employing carbons of the ordinary round type, *i.e.*, without projecting ribs, teeth, &c. This lamp is shown in Fig. 1. The

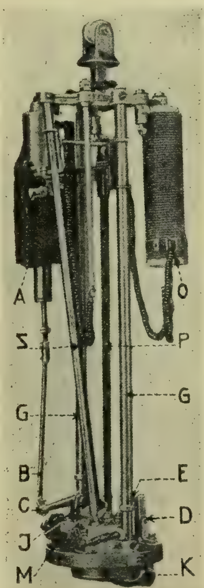


Fig. 1—View of Parts of "Conta" Lamp.

negative carbon, P, which occupies a vertical position, rests with its lower end on a support, K. By releasing a screw this support can be slightly adjusted, and is so arranged that only the outer edge of the cathode rests thereon (see Fig. 2). The movements of the carbons are interdependent.

* *Elektrot. Zeitschrift*, 1907, p. 992.

† *Elektrot. Zeitschrift*, 1909, p. 343.

When the arc is struck the cathode points itself so that the point rests on the support. (We shall see later what is the explanation of this "point" being formed.)

The support forms a part of the angular lever, D, which is capable of rotation about a horizontal axis. The upper part of this lever carries the horizontal clutch, E. The arm attached to this clutch receives the weight of the carbon and carbon-holder, and is thus pressed against the negative carbon; at the same time the carbon is forced against the inner edge of the aperture through which it passes. In addition, since somewhat thin carbons are employed, the negative carbon bends slightly under the pressure. The clutch-arrangement thus admirably answers the purpose of relieving the point from excessive pressure. The premature breaking away of the point is thus hindered,* and the building up

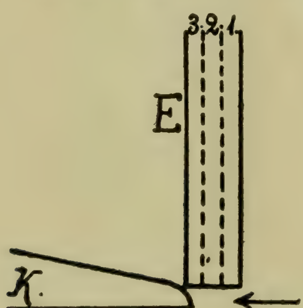


FIG. 2.

of a long point rendered possible. If, however, the supporting point does break away, the pressure of the clutch is released and the carbon allowed to drop.

By the aid of the simple mechanism described above, the lamp is automatically cut out of circuit when the carbons have burned away to a certain point. For if the negative carbon burns so low that its extremity is very near the clutch-arm, the latter presently passes above the holder and then draws the angle-lever in such a way as to remove the support from the point above it; the negative carbon is thus no longer supported, and falls out of its holder into the ash-pan below.

The striking of the arc is accomplished in the usual way by the action on an iron core of the solenoid, A. The number of turns in the solenoid is, however, so proportioned that an excess of current of even 50 per cent does not occasion any sinking of the iron core. The carbons thus remain the same distance apart, and the arc is not influenced in any way by this striking solenoid. A blow-magnet, M, is fixed on the upper side of the economizer, of which more will be said later.

Let us now turn to some of the physical phenomena connected with this new "Conta-Lamp" as it is termed. The question arises, How are we to explain the formation of the point on the lower end of the negative carbon? I was originally of the opinion that the sole explanation lay in the heat communicated by the

FIG. 3.

supported carbon to the metallic support below it. Owing to this conduction of heat the portion of the carbon in actual contact with the metallic support will have a lower temperature than the portions which are more distant. Consider now the electrode (E in Fig. 2) to be divided into a series of layers by planes which are perpendicular to the direction of the current through the arc, as indicated by the dotted lines in the figure. Then it may be supposed that the temperature of layer 1, and hence also the rate of burning away of this layer, is greater than in the case of layer 2; the burning away in the latter case will, in turn, be presumably greater

* We are only concerned here with the detachment of very fine particles.

than in the case of layer 3, and so on. The carbon would thus assume the shape indicated in Fig. 3.

More recent researches, however, led me to the discovery that a point of exactly the same nature is formed when the supporting piece is composed of some badly conducting material, and I am therefore inclined to suppose that the access of air to the carbon, at its point of support, plays an important role in determining the formation of this point. As the hot gases from the arc stream upwards, to be replaced by cooler air from the atmosphere, it is evident that a part of the carbon will be shielded by its support from the rising stream; and this will be specially true of the portions in the immediate neighbourhood of the area of contact. Now the upward course of the heated air is best represented, not by the column 1 (Fig. 4), but rather by column 2. Returning, therefore, to the consideration of the supposed layers in the electrode, it would appear that most air strikes the layer 1 and least the layer 3. The greater part of the negative carbon, which wastes away at the point of contact, combines with oxygen without being influenced in doing so by the passage of the electric current. The effect, however, varies from layer to layer, being least in the case of layer 3; the carbon must, therefore, tend to become pointed.

In the Conta Lamp it is of considerable consequence that this point should be a long and fine one. The arc naturally tends to locate itself on the uppermost point of the carbon as the temperature is there greatest; as a result the support itself does not come into actual contact with the arc, and is, therefore, not melted or converted into vapour, as might otherwise be the case. In this connexion it may be noted that a protecting layer of oxide is usually formed on the surface of this support.

The question may next be raised whether the unsupported positive carbon (the motion of which, as explained above, is connected with that of the negative), may not, owing to inequalities in the material or other causes, become shorter or longer than the negative, with the result that the arc may also become too short or too long. In this connexion it may be pointed out that in practice we are not so much concerned with the absolute length of the arc as with the relative changes which take place; moreover, the length of the arc itself is not the same as the distance between the points of the carbons; for the effect of the blow-magnet is to spread the arc outwards and to tend to increase its length. As a result a temporary alteration in the distance between the carbons has only a relatively small effect on the length of the arc.

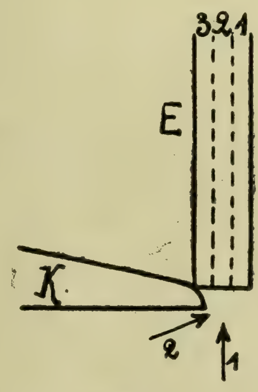


FIG. 4.

That no very appreciable difference in length of the positive and negative carbons actually arises is, in my opinion, largely to be ascribed to the action of the economizer. Imagine, for instance, that the positive carbon burns away too rapidly so that its tip retreats into the economizer. Now the wasting away of the positive carbon can be attributed to two distinct causes. First there is the loss due to vapourization in order to provide a bridge of vapour and enable the current to continue flowing.

Secondly, part of the carbon is merely oxidized without being converted into vapour. That this last effect is the predominant one is shown by the behaviour of the enclosed arc-lamp.

Now when the positive carbon-tip is withdrawn into the economizer somewhat, as explained above, the access of air to it is naturally hindered, for the space within the economizer is mainly filled with the heated gases developed in the arc, which are naturally relatively poor in oxygen. Just in the same way, if the positive carbon tends to become too long, its end projects outside the economizer into the region where more oxygen is available, and its rate of wasting away is, therefore, accelerated until it again attains its proper length. Thus the effect of the economizer is to act as an automatic regulator of the rate of wasting of the carbons.

The P.D. across the lamp, moreover, is only slightly affected by alterations in the arc-length, since the fall of potential in the vapour of the arc is but a comparatively small fraction of the total P.D. between the electrodes. The chief fall of potential occurs at the surface of the anode in contact with the arc-vapour, and there is another drop, much smaller however, at the cathode. In this respect one might compare the arc with an electrolytic cell in which there is a considerable fall of potential due to polarization, though the cell possesses a small ohmic resistance.

As a matter of fact, however, the P.D. across the lamp only undergoes relatively slight fluctuations in practice; this is shown in Fig. 5. The most marked points in this curve are to be ascribed to irregularities in the carbons ; or they may possibly occur at moments when the carbon feeds owing to the breaking away of fine particles from the supporting point. As a comparison the behaviour of a differential lamp using inclined carbons of the same variety as those employed in the Conta lamp may be studied. This is shown in Fig. 6, and it will be noted that the fluctuations are more pronounced than in the case of Fig. 5.

The blow-magnet plays a yet more important role in the Conta lamp than in the case of ordinary lamps with inclined carbons. Let us suppose that the current flowing through the arc increases owing to the presence of some chance lack of uniformity in the carbons which induces them to feed together. The field of the blow-magnet is strengthened thereby, and drives the arc upwards with increased vigour. The arc is thus both lengthened and spread out ; moreover it tends to wander towards the edge of the carbons, its apparent resistance rises, and the current is correspondingly decreased. The converse process takes place when

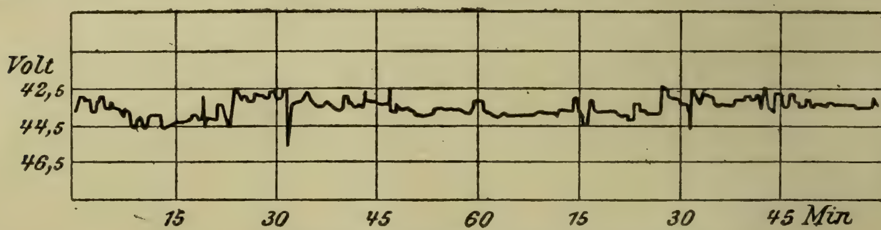


FIG. 5.—Fluctuations in Pressure of the "Conta" lamp.

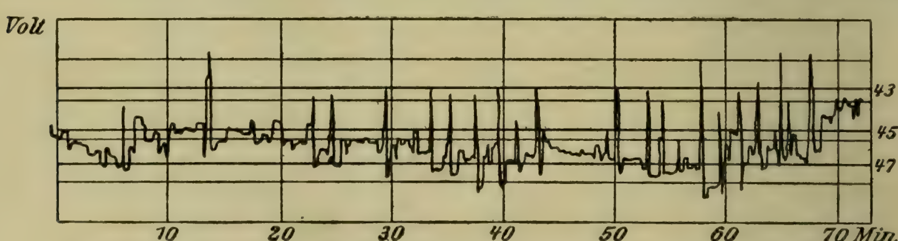


FIG. 6.—Fluctuations in Pressure of Differential Arclamp with inclined carbons.

the carbons are too far apart. The blow-magnet is also of service in preventing the position of the arc being appreciably affected by the positive carbon burning too quickly or too slowly. Thus if the positive carbon burns away too rapidly the arc assumes a position such that its distance from the blow-magnet is reduced; it is therefore driven back to its former position.

And now, when the irregularity in the carbons that primarily caused this disturbance has passed away, the distance apart of the carbons is again incorrect, the current becomes too weak, and the carbons must be fed together once more. We see, therefore, that a want of uniformity in the carbons gives rise to *four* distinct alterations in the current, namely, (1) that produced originally by the irregularity, (2) that arising from the subsequent regulation, (3) that occurring when the irregularity passes away, and (4) that taking place when the regulating mechanism once more comes into action.

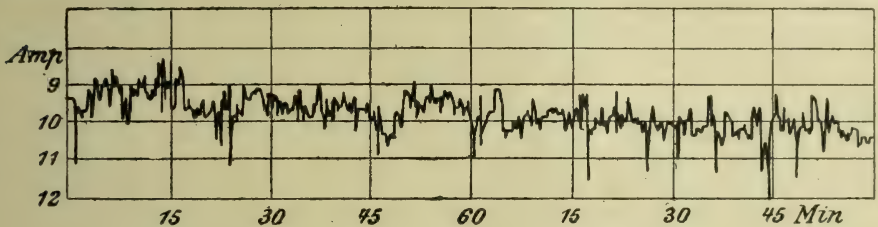


Fig. 7.—Fluctuations in current through "Conta" lamp.

It is a somewhat remarkable fact that fluctuations in current in the Conta lamp are both less frequent and less marked than is usually the case for a lamp with an ordinary so-called regulating mechanism. This is illustrated by figures 7 and 8. This effect may be explained as follows :—Suppose that in a differential lamp the carbons approach too close together, for the reasons stated above. As a result the main current is increased during a short period of time and this sets the mechanism in operation. The carbons are then drawn apart and probably, on account of the inertia of the moving parts, more than is necessary. The shunt-coil then comes into play and the carbons are in turn brought nearer together again. In this way there arise needless fluctuations set up by the regulating mechanism.

Now had the lamp possessed no regulating mechanism, the want of uniformity in question would have given rise to only two alterations in the current.

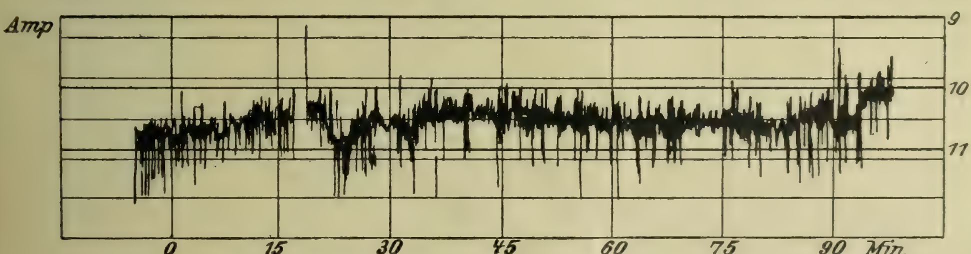


Fig. 8—Fluctuations in current through a differential arc lamp.

The new lamp is described as a "Universal" lamp because any kind of carbons, *e.g.*, pure, impregnated, or flame varieties, may be used in one and the same lamp; also because the lamp can be used for either direct or alternating circuits without changing the carbons. It may be mentioned, however, that this quality of universality does not extend to the diameter of the carbons or the current. For instance,

if it is desired to replace the existing carbons by thicker ones, the carbon-holder, etc., must also be changed. In addition, the series resistance employed does not allow any very considerable afteration in the current.

In conclusion, attention may be drawn to an important distinction between the "Conta" and other lamps of the same type. With the Conta lamp carbons fitted with projecting ribs, teeth, &c., are unnecessary, and the carbons of the ordinary variety can be used. In addition, the support of the carbon in the Conta lamp is not utilized to carry the current, and the risk of the arc travelling to the support is thus avoided. This is a thing which might otherwise happen when the contact between carbon and support is imperfect, owing to oxidation, &c. In addition, it is not necessary that the surface of the support should even be metallic; and, lastly, unlike the mechanism employed in some other types of lamps, the feeding of the carbons in the Conta arrangement depends directly and solely on the burning away of the negative carbon, and is not affected by other local conditions.

Again, the so-called regulator used as a series resistance in the Beck lamp must, in order to fulfil its purpose, be able to vary in temperature very rapidly; it must therefore consist of thin wires which carry a relatively large current, and the wire must be habitually overloaded. If the current happens to assume an unusually high temporary value, there is a danger of the wire burning through. Big variations in current are avoided in the case of the Conta lamp by the use of parallel carbons and an ordinary series resistance suffices.

An Interesting Electrical Sign.

New York seems to be particularly well served in the matter of ingenious illuminated electrical signs. In a recent number of *The Electrical World* of New York we notice a reference to several interesting examples, one of which will be seen in the adjoining illustration. This sign is located at Times Square, a position in the heart of the hotel and theatre district, where, it is estimated, 300,000 to 400,000 persons pass every twenty-four hours.

The lady shown in the sign is 40 ft. high and her parasol is 15 ft. in diameter. The movements of her skirt in the wind and the falling rain are realistically reproduced by the aid of flashing electrical lamps, the impression of falling drops of rain, it is said, being very striking.

The Fundamental Laws of Photometry and the Basis of Photometric Measurements.

On December 10th, 1909, Mr. Jacques Abady delivered a lecture at the Cripplegate Institute before the London and Junior Gas Association. The subject of the lecture was announced to be "Light and some Reflections," but it was mainly devoted to the discussion of the basis of modern photometrical measurements.

Mr. Abady began his lecture by explaining the difference in definitions and measurements on an empirical basis from those based on accurate and exact laws. A purely empirical result would be one depending on observation alone.

Mr. Abady then proceeded to give instances of things which were and were not empirical in their nature. Thus it might be said that the arbitrary selection of a certain length as the foot, and the standard of length, was empirical, but there was nothing empirical in the thing itself, which was exactly known, was quite definite in its nature, and was subject to accurate verification.

Proceeding to the subject of photometry, the lecturer mentioned that there was nothing empirical about the law of distances, the fundamental law of photometry, although we might misapply it. This law stated that the amount of light falling directly on a surface was inversely proportional to the square of the distance of the source from the surface. There was also another law applying to photometry, the cosine law, which stated that the amount of illumination received on a surface was proportional to the cosine of the angle of incidence of the rays. Though this law might be true as regards the light received by the surface, however, we must remember that the apparent brightness of the surface depended on the light reflected from it, and therefore the exact application of the law to photometry had strict limitations. He himself would prefer not to rely on it in making measurements, and he thought it was best avoided.

In the present days when new methods of illumination were arising and we had at our disposal many remarkable advances on the old flat flame burner, it was very essential that the photometrical measurements on which the claims of the respective systems were based should be exact. A very good illustration was presented by the case of street-lighting. Here the battle between the various illuminants would be fought out on the question which was best able to illuminate a given area with a certain intensity. In this connexion the lecturer mentioned an experience of his own when Chairman of the Works Committee of the Westminster City Council. A gentleman had been run over in Hanover Square, and the jury at the inquest expressed the opinion that the square was insufficiently illuminated. Yet in Hanover Square there were six arc lamps taking 40 volts and 10 amperes each, and in addition there was, at the particular point where the gentleman was run over, an incandescent lamp with three burners. Moreover, the arclamps were not more than about 30 or 40 ft. away. He thought it was possible that the jury, in advancing the view that the square was inadequately lighted, were influenced by the adjacent brilliant lighting of Oxford and Regent Streets. Regarded by itself, the square would be considered properly lighted, but it appeared not to be so by contrast. This showed the necessity that any one, in criticizing street-lighting, should be sure of his ground and be able to back his judgment by reference to definite data.

Turning next to the measurement of the candle-power of sources of light, Mr. Abady drew a distinction between the light produced by a lamp and what was termed the "illuminating effect" at a certain place in an interior, &c. In modern photometry it was a recognized necessity not to be content with measurement in a single direction, but to undertake measurements at a series of angles. This was rendered necessary by the fact that sources were no longer all of the same type, and nowadays the nature of the distribution

of light in different directions was quite distinct in the case of different lamps.

As regards "illuminating effect" the lecturer pointed out that the difficulty involved in framing a precise method of testing on these lines was that the brightness and visibility of illuminated objects did not only depend on the intensity of illumination to which they were subjected, but on their own reflective power. Any one had only to observe the difference in the appearance of Whitehall on a wet night and a dry night to appreciate this.

Mr. Abady next proceeded to discuss the various methods of achieving testing the light from a source in different angles. He pointed out that when one was testing light at any particular angle, one could not very well adjust the illumination on the photometer screen by altering the position of the photometer between the sources. For directly one changed its position one also changed the angle at which the rays of light came to it from the source investigated.

It might be possible to move the standard. This could be done, but it was often inconvenient, especially in the case of a standard like the 10 candle-power Harcourt Pentane, which was not exactly portable. It was therefore necessary to utilize some form of standard of a more portable nature, such as the electrical incandescent lamp; he frequently used such lamps himself, and they had certain advantages for this work. It was, of course, used as a secondary standard calibrated from an original standard of light. On the other hand, if one was in a place where electricity was not available, one could utilize what he considered a very satisfactory sub-standard, namely, an Argand burner with a screen in front of it having adjustable shutters. Another method of using the Argand in this way was to bring the standard quite close to the photometer, couple both together, and then determine the illumination of the photometer-disc by moving both photometer and Argand together until equality was obtained by reference to a Harcourt Standard. One could then calculate the illumination of the photometer disc in the usual way.

In passing Mr. Abady remarked that although he had at one time considered tests of M.Sph. C. P. essential, he had since come to the conclusion that a knowledge of the distribution curve and also of the candle-power in the lower hemisphere represented what was chiefly necessary.

In his previous remarks Mr. Abady had referred chiefly to laboratory testing. He next proceeded to consider the conditions to be met in testing in the streets. Here a moving measuring arrangement was necessary, and although a very wide range was often necessary, owing to the difference in the intensity of the illumination to be tested, one was usually limited in space that could be allotted to the apparatus. There were several methods which had been adopted to meet these requirements, for example, the Fox-Talbot variable rotating sector. This, however, had the drawback that special apparatus was needed to spin the disc, and there might be something empirical in its calibration.

Then there was the method of altering the inclination of the illuminated surface. Unfortunately for this method one could not secure a reflecting surface which did not result in a great deal of regular reflection, and it was impossible to rely upon the cosine law. Mr. Trotter, who first utilized this method, had stated that a perfect surface from this standpoint was unnecessary because the instrument could be graduated by experiment, but this, again, involved "empiricism." The lecturer then proceeded to criticize somewhat severely several types of instruments mentioned in the Cantor Lectures on Illumination before the Royal Society of Arts. (*Jour. of the Society of Arts*, Sept. 3, 1909.)

[In our opinion Mr. Abady would have done better to have confined himself to the discussion of scientific principles, and to have refrained from embarking upon controversy of this kind. Moreover his criticism of the Cantor Lectures is based on an entire misconception as to their object. These lectures dealt not with photometry, but with the whole field of illumination. Mr. Abady ought

therefore, to remember the enormous ground to be covered, which rendered it impossible to devote more than a few pages to the whole subject of photometry, or to embark upon a critical discussion of different types of instruments. All that was done was to describe briefly a few types in order to convey the impression that the measurement of light and illumination was now a recognized and practical process. References, however, are given to sources where fuller information can be obtained. It may be added that Mr. Gaster holds no brief for any particular instrument, and was anxious to arrange for the exhibition of all types of apparatus deserving attention. On the occasion referred to Mr. Abady was especially invited to exhibit his instrument; but after having promised to do so, excused himself at the last minute.—Ed.]

Mr. Abady wound up his lecture by describing a type of instrument devised by him into which, he said, nothing empirical entered. A small globe with a whitened diffusing interior and containing a small glowlamp was utilized as the sub-standard. In a globe of this kind a perfectly uniform interior illumination could be obtained. In front of an aperture, 15 millimetres square, in the wall of the sphere is placed an adjustable diaphragm, and by the motion of a shutter across the aperture the luminous area could be gradually reduced according to a definite law. The amount of area exposed constituted the source of light and was used to illuminate one side of the disc of a direct coupled flicker photometer. The other side of the photometer disc received light from the source to be tested. Measurements could thus be made without moving either the standard or the photometer. The travel of the shutter, and the area of the surface exposed, was registered on a drum. The voltage across the glow lamp was adjusted until, when the intensity of illumination on the flicker disc was 1 candle-foot, the reading on the drum was 100; since the scale on the drum was a proportional one a reading of say 90 or 210 would then indicate 0·9 or 2·1 foot-candles respectively. He thought that they had here a method which had nothing empirical about it.

The President (Mr. W. J. Liberty) having invited discussion, Mr. J. G. Clark said that he approved of Mr. Abady's decision in favour of the mean lower hemispherical candle-power rather than the mean spherical value. He thought, however, that the value would not be of much service unless accompanied by the distribution curve for the lower hemisphere. He was also specially interested in the use of an Argand burner with a shuttered screen in front of it. This somewhat resembled the Methven screen. It seemed to him, however, a point to be considered where the centre of illumination of such an arrangement would lie. Finally Mr. Clark drew attention to the definition of intensity of illumination as being independent of the nature of the surface and depending only on the value of the incident light. For instance, Mr. A. P. Trotter had illustrated this conception by the analogy of rainfall, which was independent of the nature of the ground, though the degree of wetness of the ground of course was not.

Dealing with these comments, Mr. Abady said it was necessary to consider both factors—the strength of the incident illumination and the surface—in order to get a proper measure of the "illuminating effect." With regard to the radiant centre of the Argand flame, the position of this was immaterial in the double comparison arrangement he had described. As a matter of fact, however, it was customary to measure from the centre of the flame.

Mr. J. S. Dow said that he was the bearer of a message from Mr. Gaster, the Hon. Secretary of the Illuminating Engineering Society, who had been kindly invited by the Chairman, but was unavoidably detained by a previous engagement.

He had listened with great interest to Mr. Abady's lucid exposition of photometrical principles, and heartily endorsed his remarks on the need for exact photometrical measurement, especially in these days when so many different systems of illumination were available. Much confusion was not

infrequently caused by the fact that the conditions under which different illuminants were tested were not strictly comparable.

Mr. Abady had also suggested that flame standards such as the Pentane standard, and electric glowlamp standards, had both their respective spheres of utility. It was interesting to observe how the gas industry were coming to take advantage of electrical apparatus for their own purposes, and Mr. Abady had shown characteristic enterprise both in adopting an electrical secondary standard for use with his interesting photometer, and in applying the diaphragm method in such an ingenious way.

Mr. Dow added that it was, of course, now well known that the inverse square law and the cosine law were only accurately true within certain limits. He thought, however, that this did not justify Mr. Abady's sweeping condemnation of all forms of illumination photometers utilizing these principles. Such instruments had been developed in Germany and the United States as well as in this country, and useful work had been done with them. Moreover, the intention of such instruments was essentially different from that of Mr. Abady. They were intended mainly as a means of readily determining the illumination at a given spot in buildings, &c. For such a purpose lightness and portability were essential, even though these qualities could only be secured by sacrificing the high degree of accuracy aimed at in the laboratory. Mr. Abady had referred to a lecture by Mr. Gaster before the Royal Society of Arts in which some instruments were briefly described. It was only fair to mention that Mr. Abady had been invited to exhibit his photometer on this occasion, but had omitted to do so.

In reply, Mr. Abady stated that he did not suggest that empirically calibrated photometers could not be used at all. But there were already so many other difficulties in photometry, personal errors, &c., as to render such methods very undesirable. He contended that such "approximate methods" were unsatisfactory because no photometrical information was better than inaccurate information. Therefore he disliked such instruments being described without qualification as to their accuracy. Though speaking before a Gas Association, he regarded himself as a perfectly impartial person. Personally, however, he had declined, and would continue to decline, to exhibit his instruments side by side with others of an approximate character which were not, properly speaking, to be described as photometers. The term photometer, if it meant anything, meant "an accurate light measurer."

In the course of further discussion, Mr. D. W. Winslow asked whether a 3,000 candle-power arc lamp would be regarded as giving the same light as the 3,000 candle-power incandescent gas lamp which contained a number of mantles and certainly seemed to give much more light. Had the concentration of the light anything to do with the matter ?

Mr. J. G. Clarke referred to the difference in the sharpness of the shadows cast by lights of different concentration.

Mr. Abady said that, as far as producing a given illumination went, he did not think the difference in concentration had much effect. On the other hand, the difference in *quality* of the light must be considered. Thus an incandescent mantle could be seen further on a foggy day.

Finally, a vote of thanks to the lecturer was proposed by Mr. Clarke, and seconded by Mr. J. Hewett. In putting the vote to the meeting, the President emphasized the fact that great changes were taking place in modern systems of illumination, and said that now that powerful sources of light were available it was most important to consider not only how much light to use, but how best to use it. In order to study such problems, the accurate measurement of light and the development of good measuring instruments were most essential.

The Problem of Heterochromatic Photometry.

By P. S. Millar.

(Abstract of paper presented at the Third Annual Convention of the Illuminating Engineering Society in the United States, Sept. 27, 28, and 29, 1909.)

In this paper Mr. Millar distinguishes two main classes of difficulties in colour-photometry—physiological and psychological. Thus he mentions the effects on photometric readings of an observer's possessing more or less abnormal colour-vision and also the "Purkinje" and "Yellow-spot" phenomena which are characteristic of the normal eye. The former effect, he mentions, becomes marked at intensities of illumination below 0·1 foot-candles.

But in addition there are psychological difficulties arising from the mere fact that the comparison of the brightness of two adjacent patches of light of different colours is in itself a difficult process for any observer. Experience is here very influential in enabling a person who at first finds himself unable to form a consistent judgment subsequently to acquire the power of doing so. Indeed it sometimes seems as if people who initially exhibited marked differences in their personal readings eventually come into agreement. Thus the author mentions two cases in his experience during the last year in which two observers using Lummer-Brodhun photometers at first differed consistently by about 3 per cent when comparing tungsten and carbon lamps. But, as a result of several months' work, the judgments of each seem to have changed to such an extent that no material difference in their settings is now found to be observable.

In dealing with comparisons of this kind the author mentions three chief devices intended to minimise these effects :—

(1) Secondary standards of substantially the same colour-value as the illuminants to be measured may be used.

(2) The colour of one of the heterochromatic lights to be tested may be varied by the use of coloured screens.

(3) Some form of flicker-photometer may be used.

However, though these methods may reduce the scope of errors due to colour-effects somewhat, they do not dispose of them ; the real difficulties of heterochromatic photometry are only postponed.

The author next procceeds to describe some experiments which he divides into two groups, (1) those involving large colour differences and including measurements at a low order of illumination, and (2) those in which comparatively slight colour-differences are met with and relatively high order of illumination is employed.

Tests Involving Marked Colour-Differences.

Mr. Millar describes a typical test, made two years ago, in which a mercury vapour lamp was compared with a line of carbon filament lamps of approximately the same dimensions ; the distances of the standard from the photometer being varied from 10 to 50 ft. With three different photometers he obtained the following results :—

TABLE I.

Comparison of Photometers in Mercury Vapour Lamps Test. Mean of Determination of two Observers.

Per cent. candle-power.

Distance lamps to Photometer. Ft.	Contrast Lummer-Brodhun. Per cent.	Bunsen Per cent.	Flicker per cent.
10	100	102	102
30	112	114	101
40	123	108	103
50	137	110	103

At a distance of 10 ft., corresponding to about 0·22 foot-candles, all three instruments gave the same result; but when the illumination was reduced to about 0·1 foot-candles the reading of the Lummer-Brodhun instrument had apparently increased by 37 per cent in favour of the mercury vapour lamp, while the value of the flicker photometer was practically the same as at the shortest distance.

At a low order of illumination these physiological effects become still more marked, and this is probably not without its effect on streetlighting problems, where the illumination is often extremely low. In this connexion the author describes some tests comparing the intensity of a titanium arclamp (yielding a very white light), with a carbon filament lamp burning at 3·1 watts per candle. Two photometers of the same general construction were placed at distances of 152 and 260 ft. from the arclamp respectively and arranged so as to measure the same intensity in the same direction in each case, namely, 4° below the horizontal. A series of readings were taken and the two instruments were then interchanged, new results taken, and a mean ratio (which should be independent of any difference in the two instruments) obtained.

As a result the titanium arc gave an apparent candlepower approximately 30 per cent higher when the photometer was most distant; this, the author suggests, might fitly be ascribed to the Purkinje effect.

Tests Involving only Slight Colour-Differences.

Under this heading the author deals with relatively small colour-differences, such as are encountered, for example, in comparing tungsten and carbon filament lamps. Originally somewhat large differences between the readings of different observers and with different types of instruments were found to occur, but eventually much more concordant results were obtained; for instance, the author gives the following series as typical:—

TABLE II.

Photometer.	Intensity of Tungsten in terms of carbon per cent.
Lummer-Brodhun contrast	100·0
Lummer-Brodhun comparison	101·5
Marten's (Bi-prism)	100·0
Bunsen (Leeson disc) ...	101·7
Flicker (Schmidt & Haensch)	101·3
Flicker (Simmance-Abady) ...	98·0

At present the explanation of the great difference in the readings of the two flicker instruments is not clear, and experiments are still being undertaken in order to see if more concordant results cannot be obtained.

As an illustration of the discordances previously experienced, however, the author gives the results of an attempt to obtain the candle-power of ten tungsten lamps in different laboratories. It is mentioned that in all three laboratories standards of light were obtained from the same source.

TABLE III.

Comparison of Candle-power as Measured in Three Commercial Photometer Rooms.

Laboratory.	Photometer employed.	
	Bunsen per cent.	Flicker per cent.
A		99·5
B	103·6	97·6
C—First photometer...	98·4	
Second photometer	100·7	

In conclusion, the author remarks that though there would seem to be no great difficulty in making a sufficiently accurate determination of the intensity of a source of a colour resembling the tungsten lamp, there is room for much further concerted work between different laboratories in order to obtain more definite information regarding these colour-phenomena; the problem is too wide for any one laboratory or any one man to deal with it.

He concludes his paper with the following recommendation:—

"That this Convention request the President to commend to the attention of the Council the need for the consideration of standardisation of methods in heterochromatic photometry, and, if it be deemed advisable, to appoint a committee to deal with the question."

The Determination of Mean Spherical Candle-Power.

By an Engineering Correspondent.

It is being gradually realized that, in the great majority of cases, the total amount of light emitted by a source is of more importance than its value in any one direction. The distribution of the light may be altered by suitable shades or globes, but it is obvious that the total amount of light can never be increased by such means. This total amount of light is sometimes called the "luminous flux" of the source and is closely related to the mean spherical intensity.

The mean spherical intensity or mean spherical candle-power of a source of light may be defined as the candle-power which would be possessed by a source radiating the same luminous flux equally in all directions. From this definition it will be seen at once that the mean spherical candle-power of a source is a direct measure of its value as an illuminant.

In some cases, in which practically all the light is concentrated into a hemisphere round the source (*e.g.*, continuous current arc lamps) the mean hemispherical candle-power is the more convenient figure. In a number of cases, notably incandescent electric lamps, a constant ratio exists between the mean spherical candle-power and the mean horizontal candle power, and such ratios, called "reduction factors,"

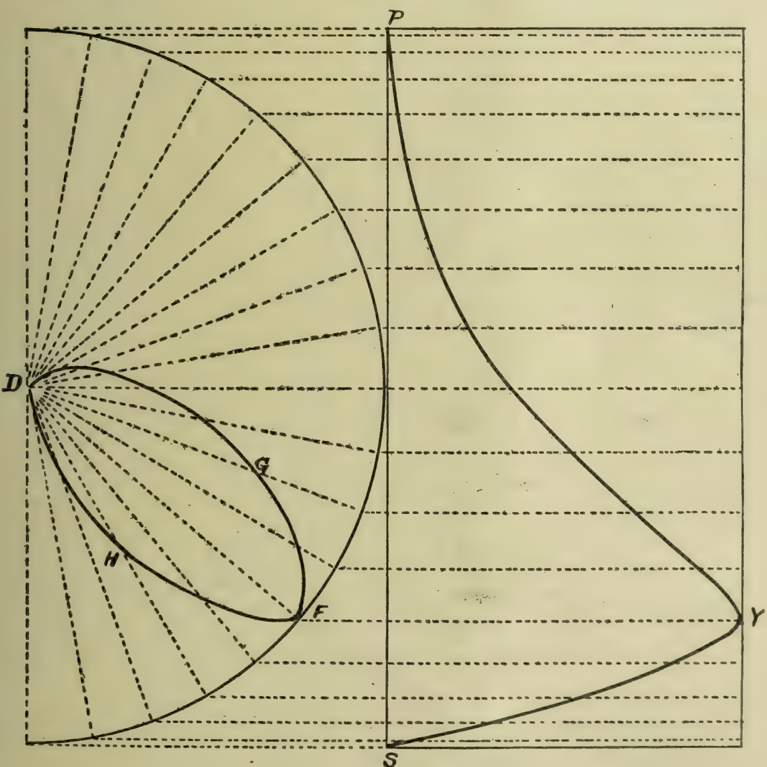


Fig. 1.

may be conveniently used when a large number of lamps of the same type have to be rapidly compared.*

Attention having now been directed to the importance of the unit, the methods available for its measurement may be examined.

Almost all methods of spherical candle-power measurement depend on the following mathematical expression for the mean spherical candle-power :—

$$\text{M.S.C.P.} = \int_0^{\frac{\pi}{2}} I_\theta \cos\theta \, d\theta,$$

where I_θ is the candle-power in a direction making an angle θ with the horizontal.

This formula follows almost immediately from the above definition of the mean spherical candle-power on the assumption of a distribution which is symmetrical about a vertical axis.

The mean spherical candle-power of a source of light may be found by methods which fall broadly into two classes :—

(*a*) Those in which the source is photometred in certain specified directions and the M.S.C.P. calculated from these observations.

(*b*) By the use of spherical photometers giving the M.S.C.P. at one reading.

Class A.

One of the oldest and certainly the best known method of this class is that known as the *Rousseau diagram*, which has been used for some years in arc lamp photometry. It will be unnecessary to give more than a very brief outline of this method.

The intensity of the source is observed at several angles in a vertical plane and the observations plotted in a polar curve as D G F H (Fig. 1). The polar co-ordinates of this curve are then transferred to rectangular co-ordinates as shown at P Y S in the diagram. Then it can be shown that the mean ordinate of this curve gives the mean spherical candle-power to the same scale as that to which the polar curve was drawn.

In order to determine the mean ordinate the area of the curve P Y S must be found by planimeter or otherwise, and in order to get rid of this troublesome process Kenelly has devised a method which only involves the measurement of a series of lengths.

Weinbeer* has considerably simplified Kenelly's construction and reduced it to the following very convenient form :—

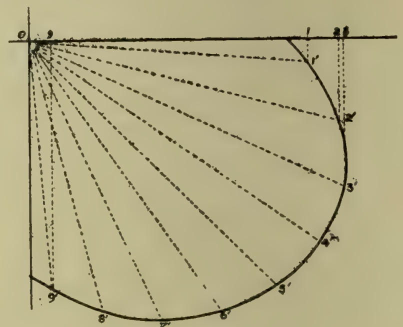


Fig. 2.

Let the curve $1^1\ 2^1\ 3^1$ ---- 9^1 (Fig. 2) represent one quadrant of the polar diagram of the source obtained in the usual way. Project the points $1^1\ 2^1\ 3^1$ ---- 9^1 on to the horizontal through the source O as 1, 2, 3 ---- 9.

Then the mean hemispherical candle-power to the same scale as the polar curve $= (O_1 + O_2 + O_3 + \ -- \ + O_9) \times \frac{\pi}{2x}$, x where $=$ number of equidistant points as $1^1\ 2^1\ 3^1$ ---- 9^1 taken in the quadrant.

Weinbeer has still further simplified his method by devising a slide rule for performing the above operations.

The slide rule (Fig. 3) is of the usual type with middle slide and cursor, but the graduations are based on trigonometrical instead of an exponential function. (The cursor is not shown in the figure.)

The slide is divided into eight sections designated 5, 15, 25, ---- 75 degree sections, the length of each section corresponding to the superficial area of the indicated 10 degree zone of a sphere, and is subdivided decimally.

* G. B. Dyke 'On the Practical Determination of the Mean Spherical Candle-Power of Incandescent and Arc Lamps,' *Proc. Phys. Soc. Lond.*, Vol. XIX., p. 136, *et. seq.*; *Phil. Mag.*, January, 1905.

* E. W. Weinbeer, *Illuminating Engineer*, Lond., Vol. I., p. 559; *Electrical World*, N.Y., December 26th, 1908.

An additional section, designated 85 degree section, is placed on the lower scale of the rule and is similarly subdivided.

The method is best described by considering the following set of observations :—

Elevation in Degrees.	Intensity in Candle-power.
85	87
75	83
65	76
55	67
45	56
35	44
25	35
15	25
5	0

To calculate the mean hemispherical candle-power proceed as follows :—

The heel of the slide is placed at the observed value of the candle-power in the 85° section, *i.e.*, at 87, the cursor is then moved to the value of the candle-power in the 75° section, *i.e.* 83. The slide is next brought back until the zero of the 65° section is opposite the censor line and the cursor then advanced to 76, the candle-power in the 65° section. The slide is again moved until the zero of the 55° section is opposite the cursor line and the cursor advanced to 67 in the 55° section, and so on. The final position of the cursor as read on the upper scale of equal divisions gives the mean hemispherical candle-power ; in this case 65. The whole series of operations is performed very rapidly and without any graphical construction whatever. The mean spherical candle-power may be obtained by repeating the above process for the upper quadrant and taking the mean of the two results.

Wöhlauer* has devised a special sectional ruled paper called "Fluxolight Paper" similar in principle to the Weinbeer slide rule by means of which the same result may be obtained.

Both of these methods assume the light source to be symmetrical about a vertical axis, and if this is not the case the source must be rotated or a large number of sets of readings taken in different azimuths round the source. The chief objection to these methods is the large amount of time occupied in obtaining the necessary experimental data and the care required to maintain the constancy of the source over the whole of this period. The advantage is that the polar curve of distribution of intensity is obtained, which is an important point in some cases.

CLASS B.

Passing on to the determination of mean spherical intensity by the use of Spherical Photometers, the first we shall mention is

The Matthews Integrating Photometer.

This photometer was designed by Mr. C. P. Matthews, and has been considerably used in the United States.

The instrument* consists of pairs of mirrors from ten to twenty in number, arranged in a semi-circle in a vertical plane in such a manner that light emitted from the source at any angle is reflected back so as to fall on the photometer screen at the same angle, both source and photometer being situated at the centre of the mirror system. A diagram of the arrangement showing only one pair of mirrors is shown in Fig. 4 in which S is the source, M M the pair of mirrors, P the photometer screen, and L the standard lamp.

Now Lambert's law states that if light is incident on a surface at an inclination making an angle Θ with the normal to that surface then the resultant brightness of the surface is proportional to cos Θ.

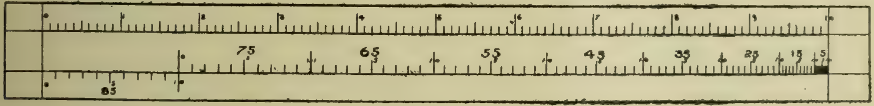


FIG. 3.

* Wöhlauer, *Illuminating Engineer*, N.Y., February, 1909.

* G. B. Dyke, *Proc. Phys. Soc. Lond.*, Vol. XIX., p. 136, *et seq.*

Hence it follows that the brightness of the photometer screen in the Matthews photometer is proportional to

$$\Sigma\ I_\theta \cos\Theta$$

where $I\theta$ is the intensity of the source in a direction making an angle Θ with the horizontal.

And therefore, if the mirrors are sufficiently numerous, the brightness of the screen is proportional to

$$\int_0^{\frac{\pi}{2}} \cos\Theta\ d\Theta$$

and hence to the mean spherical candle-power.

Variations in the co-efficient of reflection of the mirrors and errors due to the non-fulfilment of Lambert's law by the photometer screen are compensated by adjusting the mirrors radially so as to increase or diminish the distance which any particular ray has to travel from source to screen. The instrument is very convenient, and in careful hands is capable of giving very accurate results. It can be used to obtain the polar intensity curve of the source by covering all the mirrors except those at the angle required.

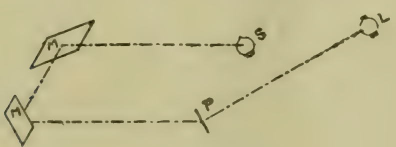


FIG. 4.

Its disadvantages are :—

Its inconvenient size, the instrument standing from eight to eleven feet high.

The skill necessary to make the requisite preliminary adjustments, and to determine the constant of the instrument.

If the light source is not symmetrical about a vertical axis it must be rotated, or a large number of readings taken in different azimuths. For arc lamp work the apparatus becomes somewhat unwieldy, especially if globes are employed. A modification of the instrument for arc lamps has diffusing screens between the mirrors of each pair in order to reduce the illumination on the photometer screen.

The Krüss Integrating Photometer.

Introduced by Dr. Hugo Krüss* of Hamburg.

This photometer is on the Matthews principle, and has eighteen mirrors in the semi-cumference.

Considering the relation

$$M.S.C.P. = \tfrac{1}{2}\int I_\theta \cos\Theta\ d\Theta$$

$\cos\Theta$ is allowed for in the Matthews photometer by utilizing Lambert's law, but in the Krüss instrument each ray is made to pass through a lens to which is attached a stop, which is so adjusted that the emergent ray is of intensity $I\theta \cos\Theta$. Fig. 5 gives a diagram of the path of one ray through the instrument.

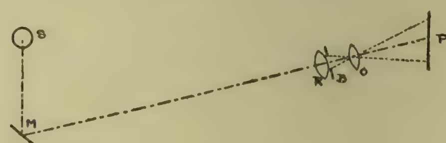


FIG. 5.

Light from the source S is reflected by the mirror M to the lens R fitted with the stop B, then passes through the lens O and forms a disc of light on the photometer screen P. The instrument is more compact than the Matthews, but the lens system is complicated and difficult to adjust. With these exceptions the remarks made concerning the Matthews photometer apply equally to the Kruss instrument.

* H. Krüss, *Gas World*, March 16th, 1909.

(*To be continued.*)

G. B. D.

A Comparison between the Illuminating Efficiencies of Carbon Monoxide and Hydrogen when used in conjunction with the Incandescent Mantle.

By ARTHUR FORSHAW, M.Sc., Institution Research Fellow in the Department of Fuel and Gas Engineering, University of Leeds.

(Paper read at the Annual Meeting of the Institution of Gas Engineers, London, June 15, 1909; we are indebted to the courtesy of the Council of the Society for permission to publish this paper and to the *Gas World* for the loss of the blocks by which it is accompanied.)

(*Concluded from Vol. I., p.* 672.)

THE consumptions of carbon monoxide shown in Table IV. were the highest that had been used up to this stage of the work. Comparable rates of consumption of hydrogen are shown in Table IVA.

TABLE IVA.

H_2.	Air.	C.P.	$\frac{C.P.}{H_2}$	$\frac{Air.}{H_2}$
2·4	0·94	9·47	3·94	0·39
2·92	Nil	5·38	1·84	Nil
3·44	1·22	9·0	2·62	0·36

The difference in "duty" afforded by hydrogen and carbon monoxide in all the experiments so far considered is striking. In Tables II. and IIA., the duty for carbon monoxide is considerably more than double that shown

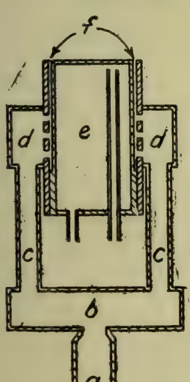


FIG. 1A.—Section of burner heads 3a and 3b.

by hydrogen under similar conditions. In Tables IV. and IVA., the duty afforded by carbon monoxide was also very much superior to that afforded by hydrogen, but the comparison is, in this instance, perhaps not altogether a fair one. For whereas in the case of the carbon monoxide the flames were

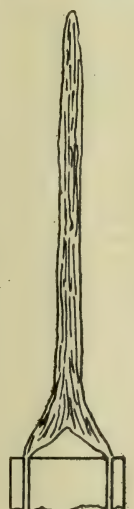


FIG. 2.
H_2 flame well aërated.

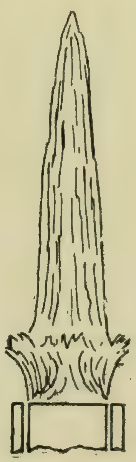
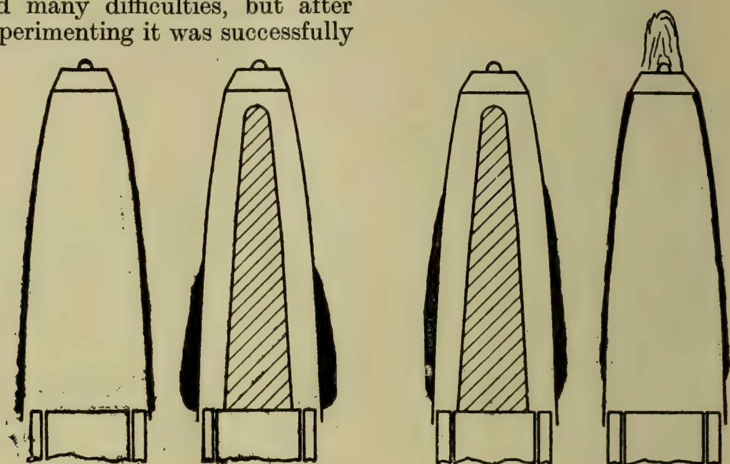


FIG. 3.
CO flame well aërated.

all well aërated, in the case of the hydrogen they were badly aërated, although as highly aërated as the construction of the burner would permit. It has nevertheless been shown that in all cases where hydrogen and carbon monoxide have been compared under similar conditions of aëration, the advantage has always been over-whelmingly in favour of carbon monoxide. Moreover, since with any ordinary atmospheric burner carbon monoxide may be burned with a much greater degree of aëration than is possible to obtain with hydrogen without the flame striking back, it may be concluded

that, under such conditions, carbon monoxide will give a higher maximum duty at every rate of consumption.

The problem of designing a form of burner which would permit of a thoroughly aërated hydrogen flame presented many difficulties, but after much experimenting it was successfully is burnt. The inside surface of the slit is the circular water jacket *e*, which cools the gaseous mixture while the restricted width of the slit causes the mixture to move forward towards the flame at a high velocity.



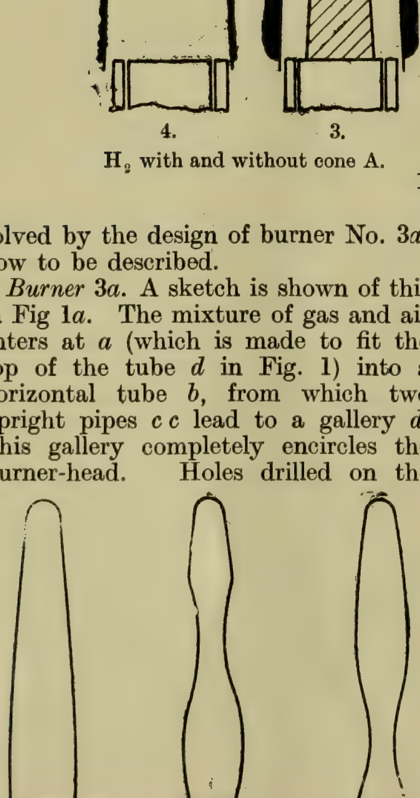
4. 3. 1. 2.

H_2 with and without cone A. CO with and without cone A.

FIG. 4.

solved by the design of burner No. 3*a*, now to be described.

Burner 3*a*. A sketch is shown of this in Fig 1*a*. The mixture of gas and air enters at *a* (which is made to fit the top of the tube *d* in Fig. 1) into a horizontal tube *b*, from which two upright pipes *c c* lead to a gallery *d*. This gallery completely encircles the burner-head. Holes drilled on the



Cone A. Cone B. Cone C.

FIG. 5.

inside of the gallery allow the passage of the gas and air into the slit *f*, which also extends all round the burner head, and from the top of which the mixture

It is obvious that such a burner as the above is very far removed from anything that is likely to be used in actual practice, and that therefore in some respects the remaining experiments may be said to have been carried out under quite artificial conditions. But since the object of the research was the comparison of the illuminating efficiencies of hydrogen and carbon monoxide both burning under the most favourable conditions, it seemed neither necessary nor desirable to impose any arbitrary limit as to the design of a burner. In the first experiments with the new burner, the width of the slit was only 0·074 in., and whilst it was possible to maintain a fully aërated flame of hydrogen without any danger of it striking back, the extremely narrow opening only permitted of comparatively low rates of consumption. In these circumstances, very poor results were obtained as regards maximum efficiency. On investigation, this seemed to be due primarily to the shape of the flame, which is shown in Fig. 2. It assumed a long, tapering pencil-like form, and although this is not neces-

sarily an indication of its shape when the mantle was placed in position, it obviously did not particularly conform to the outline of the mantle. Nevertheless, even with this burner, under similar conditions as regards aëration, a 40 per cent higher duty was obtained with carbonic oxide than with hydrogen. The slit of the burner was now widened to pass 50 per cent more gas than in its original condition; and the final experiments were performed with the burner head thus altered. Under the new conditions, it was at length possible to follow the maximum duty curve for hydrogen with increasing consumptions up to a point at which it ceased to rise.

Such a slit burner, however, is not well adapted for the combustion of obtained by means of burner No. 2 for carbon monoxide. This comparison is shown in Tables V. and VI. The "duty" curves constructed from the figures in Tables V. and VI. are compared in Diagram IV.

TABLE V.

H_2.	Air.	C.P.	$\frac{C.P.}{H_2}$	$\frac{Air.}{H_2}$	$\frac{C.V. \times H_2}{C.P.}$
3·98	4·31	18·4	4·62	1·08	16·0
5·01	5·92	32·2	6·43	1·18	11·5
5·04	6·68	36·2	7·18	1·32	10·3
5·92	8·65	44·6	7·53	1·46	9·8
6·07	9·24	49·5	8·16	1·52	9·06
7·46	12·76	78·7	10·55	1·71	7·00
7·65	13·67	86·5	11·31	1·78	6·54
8·35	14·25	96·5	11·56	1·71	6·39
9·13	15·13	108·0	11·76	1·65	6·3

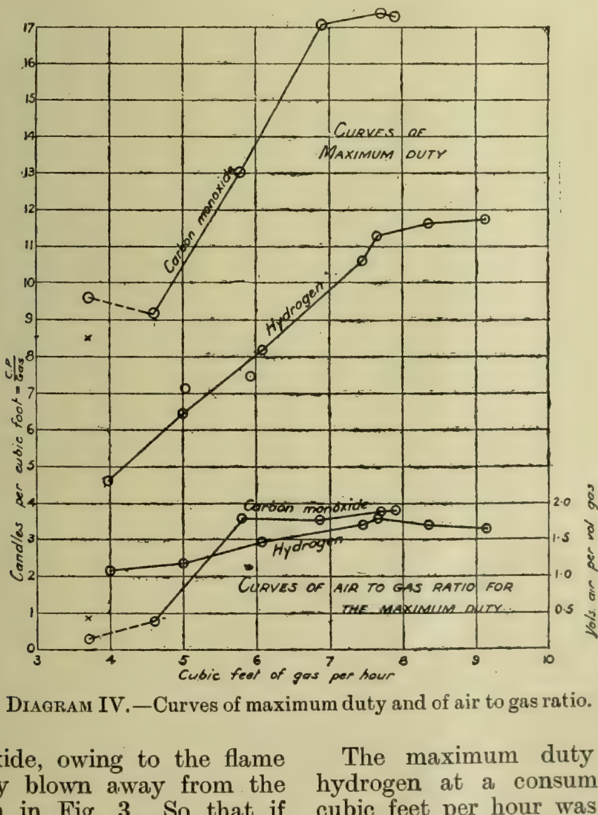


DIAGRAM IV.—Curves of maximum duty and of air to gas ratio.

carbon monoxide, owing to the flame being partially blown away from the slit, as shown in Fig. 3. So that if hydrogen and carbon monoxide are to be finally compared under the most favourable circumstances for each, the results obtained with the slit burner for hydrogen must be compared with those

The maximum duty obtained for hydrogen at a consumption of 9·13 cubic feet per hour was 11·76 candles per cubic foot—a result which must be compared with the 17·33 candles per cubic foot obtained for carbon monoxide at a consumption of 7·69 cubic feet per hour. The ratio of the

maximum efficiencies for carbon monoxide and hydrogen is therefore 1·47, as compared with a ratio of 1·13 for their net calorific values.

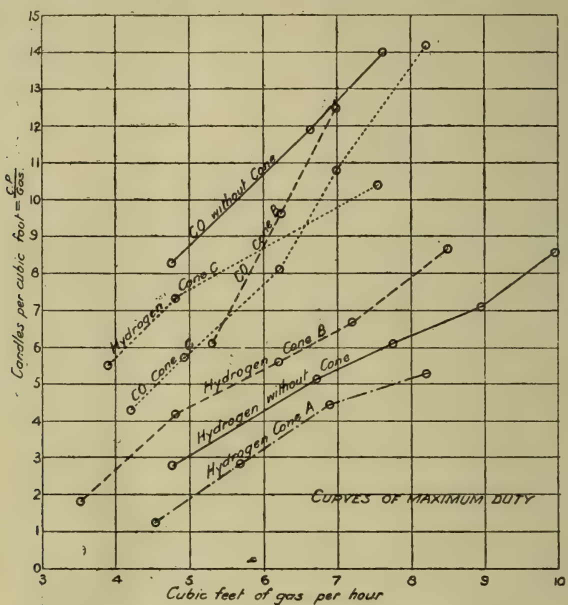


DIAGRAM V.—Curves of maximum duty.

VARIATION OF THE SHAPE OF THE FLAME AND ITS INFLUENCE UPON THE "DUTIES" OBTAINABLE FROM THE GAS.

The experiments on hydrogen with the slit burner had suggested the desirability of endeavouring to alter the shape of the flame by the use of porcelain cones, so as to confine the combustion as far as possible to a hollow shell corresponding to the outline of the mantle. For this purpose, hollow cones of white porous porcelain of three different shapes, as shown in Fig. 5, were prepared for us by Messrs. Doulton & Co., of Lambeth. The surface of cone A was so made as to be parallel to the surface of the mantle, while the outlines of the other two cones were designed for the purpose of deflecting the flame as much as possible, either towards the battom or towards the top of the mantle as circumstances

TABLE VI.

Co.	Air.	C.P.	C.P./Co.	Air./Co.	C.V. × Co./C.P.
3·72	0·61	35·53	9·57	0·16	8·73
4·62	1·81	42·4	9·18	0·39	9·1
5·8	10·55	75·5	13·05	1·83	6·4
6·87	12·27	117·2	17·06	1·78	4·89
7·69	14·64	133·2	17·33	1·90	4·82
7·91	15·22	137·0	17·31	1·92	4·82

TABLE VII.

Diagram and Curve.		H_2.	Air.	C.P.	C.P./H_2.	Air./H_2	C.V. × H_2/C.P.
		No Cone					
VI.	a_1	{ 9·68	15·37	85·5	8·84	1·59	8·36 }
	a_2	} 9·94	14·64	[85·5	8·60	1·47	8·59] }
	b	8·95	13·02	63·5	7·10	1·45	10·41
	c	7·77	10·94	47·5	6·11	1·41	12 10
	d	6·69	8·14	34·5	5·16	1·22	14·33
	e	4·75	4·29	13·05	2·75	0·90	26·88
		Cone a					
VII.	a	10·03	13·65	40·0	3·99	1 36	18 52*
	b	8·22	13·10	43·8	5·33	1·59	13·87
	c	6·87	10·93	30·7	4·47	1·59	16·53
	d	5·65	7 96	16·2	2·87	1·39	25·76
	e	4·52	5·06	5·7	1·26	1·12	58·57
		Cone b					
VIII.	a	8·5	15·63	73·4	8·63	1·85	8·56
	b	7·21	12·66	48·0	6·63	1·76	11·10
	c	6·19	10·26	34·55	5·58	1·66	13·24
	d	4·81	7·17	20·15	4·19	1·48	17·62
	e	3·51	4·62	6·35	1·81	1·31	40·87
		Cone c					
IX.	a	8·58	14·02	82·6	9·63	1·63	7·67*
	b	7·52	12·54	78·3	10·42	1·67	7·09
	c	6·78	8·76	45·02	6·69	1·30	11·05*
	d	4·80	6·18	35·2	7·34	1·29	10·07
	o	3·87	5·07	21·3	5 50	1·31	13·44

* Evidently short of air.

TABLE VIII.

Diagram and Curve	CO.	Air	C.P.	C.P./CO.	Air/CO.	C.V.+CO / C.P.
	No cone					
X. a	7·61	13·32	106·5	13·99	1·75	5·97
b	6·62	12·77	79·5	12·01	1·93	6·95
c	6·03	9·33	57·5	9·54	1·55	8·75
d	4·76	1·11	39·3	8·26	0·23	10·11
	Cone a					
XI. a	7·38	13·95	88·5	11·99	1·89	6·96
b	6·57	12·29	72·0	10·95	1·87	7·62
c	5·80	9·64	61·8	10·65	1·66	7·84
d	4·46	4·11	23·75	5·32	0·92	15·70
	Cone b					
XII. a	8·14	14.6	108	13·26	1·79	6·3
b	6·98	11·40	87·8	12·57	1·63	6·63
c	6·24	8·28	60·0	9·62	1·33	8·68
d	5·31	6·70	32·6	6·14	1·26	13·59
	Cone c					
XIII. a	8 2	14·4	116·2	14·19	1·76	5·89
b	6·98	10·24	75·5	10·81	1·47	7·72
c	6·23	9·30	50·5	8·11	1·49	10·3
d	4.93	3·82	27·4	5·68	0·77	14·7
e	4·18	2·09	18·05	4·31	0·5	19·36

certain places. As might be expected, the alterations thus caused in the contour of the flame affected the curve of maximum duty at different consumptions in a marked manner. The effect of using the cones is shown in Tables VII. and VIII., from which the duty curves in Diagram V. have been constructed.

One fact is made plain from a consideration of these tables and diagrams—namely, that both for hydrogen and carbon monoxide the curve of "maximum duties" is altered considerably by the cones as far as it has been possible to follow it, and that differently shaped cones have different effects. Two reasons may be advanced in explanation of this alteration of the curves, they are :—

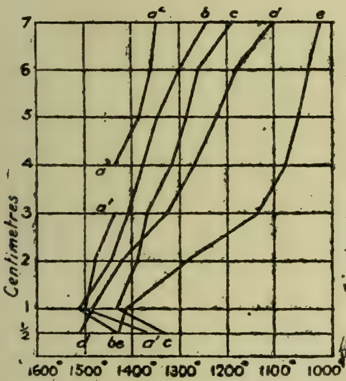


DIAGRAM VI.—H_2 without cone.

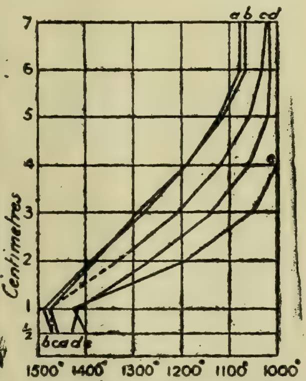


DIAGRAM VII.—H_2 with cone A.

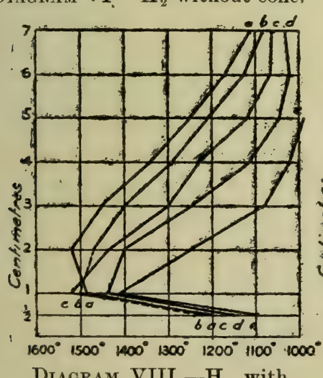


DIAGRAM VIII.—H_2 with cone B.

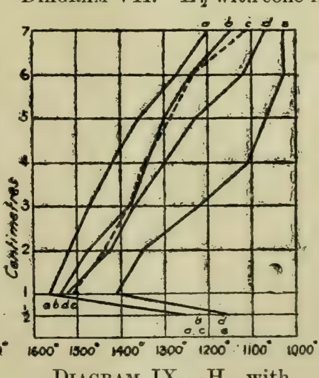


DIAGRAM IX.—H_2 with cone C.

ILLUMINATION CURVES FOR HYDROGEN.

might seem to require. In comparing the cones as shown in Fig. 5, it will be noticed that B and C are both derived from A by reducing the diameter in

1. The "quickening" or concentration of the flame owing to increased surface combustion, or some such similar cause.

2. The deflection of the flame according to the shape of the cone.

In considering the first, it is necessary to look at Fig. 4. This consists of four sketches, showing the relative distribution of brightness of the illumination given by (*a*) carbon monoxide with cone as in sketch No. 1, and without a cone in sketch No. 2; (*b*) hydrogen with cone as sketch No. 3; and without a cone in sketch No. 4. always the case. Concentration of the illumination invariably occurs when any cone is used, but increase in total candle power is not always effected by concentration.]

Hydrogen. In Diagram VII., it is seen that with cone A the illumination is principally at the bottom of the mantle, and falls away rapidly as the upper portions are approached; whereas in Diagram VI., without a cone, the

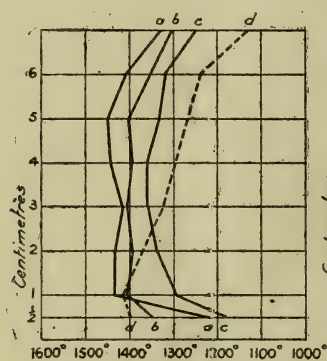


DIAGRAM XII. CO with cone B.

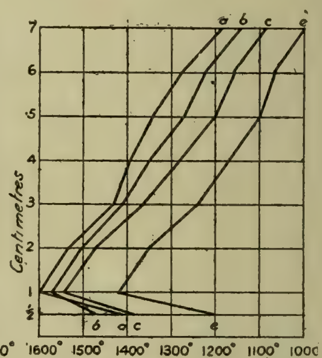


DIAGRAM XIII.—CO with cone C.

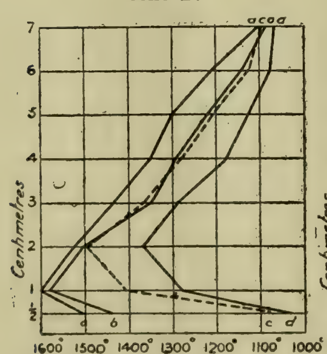


DIAGRAM X.—CO without cone.

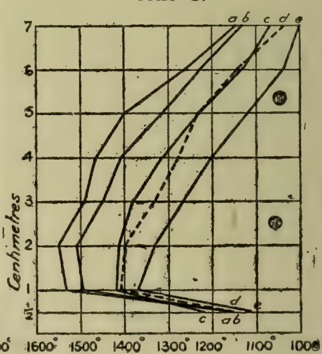


DIAGRAM XI.—CO with cone A.

ILLUMINATION CURVES FOR CARBON MONOXIDE.

The illumination is distributed in a very equal manner over the mantle surface when the cone is not in use. On the contrary, when the cone A is in use the illumination appears to be mostly on the bottom parts of the mantle, and is much more brilliant—a statement which is proved in the particular experiments illustrated by the fact that the duty afforded was higher in both cases with the cone than without it. [This is not, however, falling away is not nearly so rapid, and the upper portions of the mantle are comparatively well illuminated. In Diagram VIII., the effect of cone B is shown to be in the same direction as cone A at the bottom of the mantle, but at the top it allows of better illumination. In Diagram IX., cone C, with its slender bottom and bulging top, causes the flame which has partially escaped the previously-mentioned quickening action of the wide bottomed

cones A and B to be deflected on to the upper portions of the mantle, with a consequently improved illumination there.

Carbon Monoxide. The effects are very similar. Without a cone (Diagram X.), there is a very even illumination over the mantle surface. Cones A and B (Diagrams XI. and XII.) cause quickening of combustion and better illumination at the bottom and less in the upper portions, whilst cone C (Diagram XIII.), causing less quickening, and concentration of illumination at the bottom, gives a better illumination at the top of the mantle than the other cones.

Returning to the effect of the cones on the duty curves (Diagram V.), it must be concluded that, as far as the curves go, they show that the duty afforded by hydrogen can be raised by the use of a suitably shaped cone. In the case of carbon monoxide, no actual improvement is effected by the cones, though the direction of the duty curves when the cones are used indicates a quicker rise of duty for a given increase in the rate of consumption than without them. Could the curves be further extended, it is possible that the horizontal part of the steeper curves would be higher than that for the less steep curve for carbon monoxide without a cone. As this can only be settled by further experiment, the only definite conclusion so far established by the use of the cones is the fact that they cause quickened combustion, and therefore concentration of illumination.

Conclusions.

The principal conclusions arrived at during this investigation may be summarized as follows :—

1. When hydrogen is burnt in an ordinary atmospheric burner with a degree of aëration up to a ratio of $\frac{\text{Air}}{\text{H}_2} = 0{\cdot}5$—*i.e.*, the highest possible with such a burner—the duty afforded steadily decreases with a rising rate of gas consumption.

2. The distribution of luminosity over the mantle with such a burner is vastly different with hydrogen than with carbon monoxide under similar conditions.

3. With an ordinary burner, carbon monoxide invariably gives a very much higher duty than hydrogen.

4. When, by suitable manipulation, hydrogen was made to burn in a well-aërated condition, the highest duty obtained was 11·7 candles per cubic foot, with a ratio of $\frac{\text{Air}}{\text{H}_2} =$ about 1·7 This, compared with the best result for carbon monoxide — viz., 17·3 candles per cubic foot with a ratio $\frac{\text{Air}}{\text{CO}} = 1{\cdot}9$—shows a 48 per cent margin in favour of carbon monoxide. A comparison of their calorific values as used in the test shows only a 13 per cent advantage in favour of carbon monoxide.

5. The use of cones inside the mantle causes a quickening of combustion and concentration of illumination.

Annual Prize Distribution at Northampton Institute.

The annual prize distribution at the Northampton Institute (Clerkenwell, London) took place on Friday, Dec. 10th, when Sir John Wolfe Barry delivered an address in which he eulogized the work of the City companies in regard to technical education. It was also stated by the Principal, Dr. R. M. Walmsley, that 5,600*l.* was to be expended on the erection of a complete generating plant within the building, which would supply all the requirements as regards lighting and power in the Institute and also enable students to gain some insight into the working of a central station.

As usual an attractive series of lecturettes formed a feature of the evening's arrangements, and there was also an exhibition of electrical and optical apparatus on view in the laboratories.

Acetylene Lamps in Mines.

By A Paris Correspondent.

Of recent years acetylene lamps have found a wide application for use in the galleries and other parts of collieries, and have proved to be specially adapted for mine illumination, owing to the nature of the light, their cheapness, and their advantages from the hygienic standpoint.

Acetylene lamps, for example, inconvenience the worker to a much smaller extent than those burning oil. They do not smoke or flicker, and only cost about 0·08 to 0·1 francs per day for upkeep; and in addition the progress of the miner carrying such lamps is materially assisted by the brilliancy of their light, which enables him better to pick his way in the gloomy surroundings. In many mines one acetylene lamp has been able to replace four oil ones.

In Germany, where mining lamps have recently received special attention, acetylene safety lamps, specially adapted for use in mines where the presence of fire-damp is suspected, have been devised. Such lamps are completely enclosed, and are fire-damp-proof. There are also lamps for use in mines where no fire-damp occurs; at the present day these are the most generally used, and will be described in what follows.

Let us, therefore, consider the qualifications of a good miner's acetylene lamp. It must be strong, simple, and not too heavy. It must also be capable of being carried in all positions and at different inclinations without being extinguished. In order to secure this last result several factors must receive attention, but especially the tightness of the junction connecting the two parts of the lamp and the method of allowing the water to come in contact with the carbide.

These matters have been very carefully studied in an article contributed in a recent number of the *Revue des Eclairages*, by M. A. Butin, an engineer who has had considerable experience in this department. In what follows we may summarize a few of the most important points.

In all the well-known types of lamps the method of closing the juncion between the two parts of the lamps is accomplished in one of the following ways:—

1. Closure by simply screwing the two reservoirs one above the other.
2. Closure by aid of a nut underneath.
3. Closure by aid of a nut above.
4. Closure by means of the pressure of a band.
5. Closure by the use of a series of nuts.
6. Closure on the bayonet system.
7. Closure by various modifications of No. 6.
8. Closure by pressure exerted through an eccentric.

The method of spraying the water over the carbide may be automatic, utilizing a suitable valve, or the water can be regulated as may be needed by turning a screw.

The burner may be placed either at the top of the lamp, or on the portion forming part of the water-reservoir, or on the receptacle for carbide. The reflector may take different shapes, but the best type is plane.

Something may be said regarding the treatment of lamps in mines. This is usually extremely simple. All that is necessary is to clean out the reservoir before inserting a fresh charge of carbide, and to maintain in a clean and free condition the orifices by which the water reaches the carbide and the gas escapes through the burner.

Let us next turn to the description of a few of the chief types of lamps which are intended for use in mines.

The *Granat Lamp* is based on the system of simple direct closure (No. 1). It is composed of two reservoirs, made of bronze or aluminium, screwed one upon the other. The whole resembles

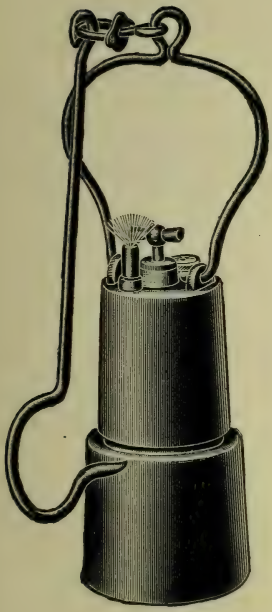


Fig. 1.—Granat Lamp.

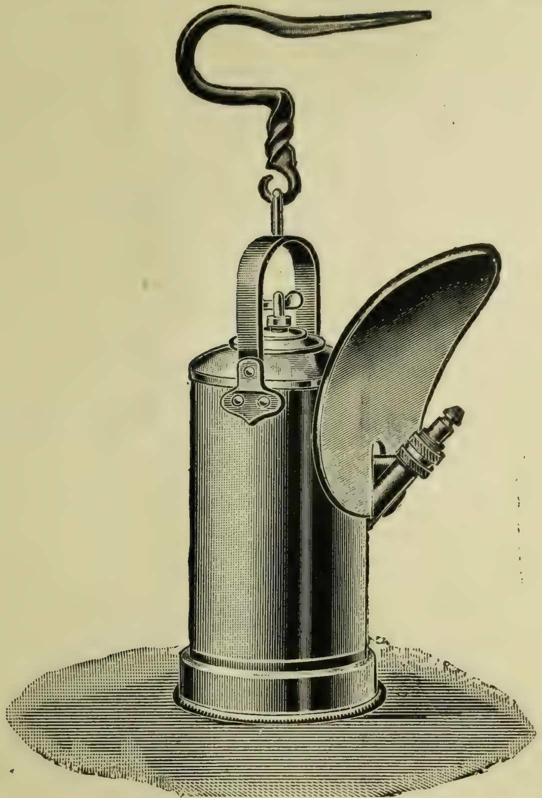


Fig. 3.—Wolfsegg-Traunthaler Lamp.

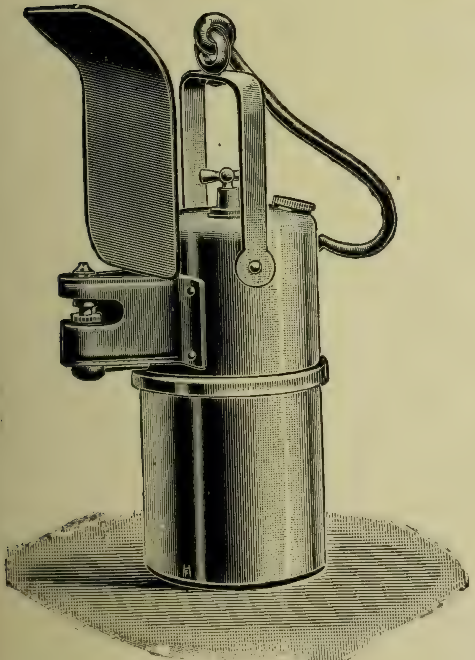


Fig. 2.—Hesse-Teller Lamp.

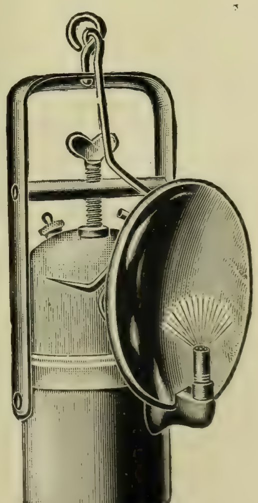


Fig. 4.—Nova Lamp.

a conical box with a polished wall. All the accessories, burner, adjusting screw, water-aperture, attachment of the handle, &c., are assembled on the top of the lamp. The flow of water on to the carbide is regulated by simply turning a screw-tap, the liquid falling straight on to the mass of carbide. The simplicity and robust character of this lamp are its chief qualifications.

The *Hesse-Teller* lamp is also of a very simple character, the method of closing being by the use of a nut immediately below the carbide-reservoir. The lower portion of the water-reservoir contains a piece of felt which serves to filter off all impurities from the gas produced. In order to obviate the necessity of regulation by the workman, the flow of water is controlled by means of a tap which in one position completely closes and in another completely opens a graduated orifice. The flow of water takes place regularly and automatically. If by chance the lamp is upset and the controlling valve rises, the flow of water ceases immediately and the lamp goes out.

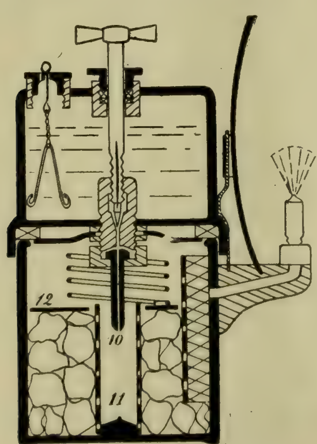


Fig. 5.—Strempel Lamp.

The *Nova* lamp, on the other hand, relies on closure by pressure. The disc covering the carbide is slightly curved and carries a tube which rests on the bottom of the reservoir, and is surrounded by a perforated vessel through which the water percolates on to the carbide. Regulation is effected by turning a screw-tap.

The *Wolfsegg-Traunthaler* lamp employs the bayonet system of closure. This joint is effected at the base of the lamp by means of a cap which presses the brim of the carbide-reservoir tight against the body of the lamp. The flow of water is regulated by a screw-cock, the alteration in position of which is recorded on a graduated dial; the spreading of the water on the carbide is facilitated by a perforated tube.

The *Strempel* lamp is closed by means of an eccentric locking device.

The water-regulation is effected by a central screw terminating in a needle orifice; this communicates with a central large perforated tube surrounded by carbide, which, as usual, is covered by a suitable disc-arrangement. The gas generated is caused to pass through a filtering chamber on its way to the burner, which is in this case at the side of the lamp.

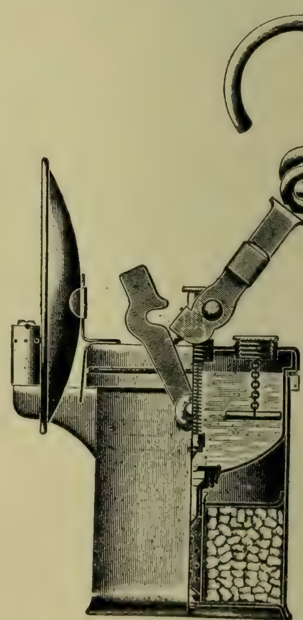


Fig. 6.—Joris Lamp.

There are, of course, other types of acetylene lamps for mines, such as the "B" lamp and the Joris, Besson, Mercier, Wolff, and other types. Enough has been said, however, to indicate the general nature of a few typical models and their sphere of usefulness.

Oil as a Lighthouse Illuminant.

By R. H. Stephens,

Formerly of Trinity House.

In few branches of science has greater progress been made in recent years than in that of lighthouse illumination. Not much more than a century ago mariners were warned of dangerous parts of the coast by enormous coal fires, which were kept burning on the tops of stone towers erected and maintained by benevolent persons on behalf of our shipping industry. This system was displaced by the introduction of candles, and the first revolving light was erected in Great Britain at St. Agnes, Scilly Isles, only about the beginning of the nineteenth century.

With the advance of science the lens was brought into use, and an improvement was made from candles to colza oil lamps of various forms. Later, paraffin oil lamps with circular wicks were used. The latest type of this lamp used by Trinity House was that of eight concentric wicks, the outer one being about 8 in. in diameter. This gave a remarkably good light, but, owing to its construction, it was very sensitive to changes in temperature, and required constant attention.

Both gas and electricity have also been introduced with more or less success, but in recent years these have met a new competitor, a description of which is the subject of this article.

The value of what may be termed incandescent oil - lighting for lighthouse illumination formed the subject of comment in a paper by Mr. J. R. Wigham before the Royal Society of Dublin in 1900. One of the most essential characteristics of a successful lighthouse illuminant is not so much high intrinsic brilliancy, as ability to penetrate the atmosphere, and it has often been maintained that the electric arc-light, for some reason, in spite of its great brilliancy, is relatively lacking in this penetrative power. The vital importance of this quality in a lighthouse illuminant was illustrated a few years ago by the loss of the liner Suevic, near the Lizard, during a dense fog.

The results of experiments of the Royal Commission at the South Foreland, about thirty years ago, favoured the view that oil illuminants, possibly on account of their being relatively rich in the red rays in the spectrum, possess greater penetrating power for a given intensity than the white electric light.

In the incandescent oil system of illumination, of which the Kitson light is a well-known example, cold petroleum vapour, in conjunction with an incandescent mantle, is utilized. As a result, a very steady and brilliant light, rich in the necessary red rays, is obtained.

Mr. Wigham describes the system as follows :—

"Under the Kitson system, the petroleum is placed in a steel receiver, capable of containing the quantity required for a light for a lighthosue or other place, for the time for which the light is to be shown. Over the oil in the receiver, atmospheric air is compressed by an ordinary air-pump to a pressure of, say, 50 lb. per square inch. This pressure remains practically constant; a very few strokes of the piston of the pump on the occasion of each new charge of petroleum being sufficient to renew the necessary pressure. The petroleum under this pressure is forced through a soft brass tube, of very small bore, by which it is conveyed to the position in which the light is placed. Being heated at that point, it is converted into combustible vapour or gas, and discharged through a needle-hole orifice. The quantity of petroleum thus heated is so exceedingly small that there is no possible danger of fire or

explosion. The tube in which this heating takes place is only about 8 in. in length, and $\frac{1}{4}$ in. in diameter. To start the lamp, the flame of a little methylated spirit is applied for two or three minutes to the heating tube, after which the heat is maintained by the light itself. The gas issuing from the needle-hole enters a wider tube of peculiar shape and dimensions, and in that tube it is mixed with air, forming a powerful Bunsen burner, which heats to vivid incandescence a mantle provided for the purpose. This mantle may be similar to the ordinary type with which we are so familiar, or may be one of stronger character and larger size. The intensity of the light is not produced by the heat alone, as in the case of the ordinary incandescent burner, but also by the high pressure at which the petroleum gas is burned, coupled with the high illuminating power of that gas."

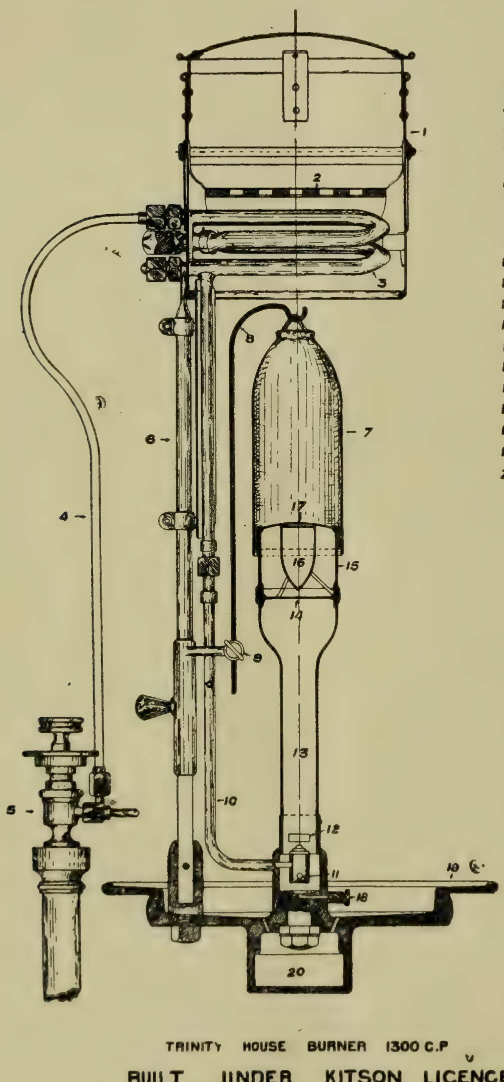


Fig. 1.

As early as 1885 attempts had been made to construct a burner for heating purposes, by injecting oil under pressure into a chamber heated by the waste heat of the flame. The jet of gas thus formed was led into an atmospheric burner, and, carrying in with it sufficient air for its own combustion, gave rise to a non-luminous flame of considerable heating power. At this time, however, the Welsbach mantles had no reached a commercial stage. Experiments on the utilization of mantles composed of fine platinum gauze led to but little practical result, and it was not until the arrival of the commercial mantle in 1895 that the application of oil-vapour to incandescent lighting met with success.

It is now possible to produce from one single mantle an illumination equal to 4,000 actual candle-power, which, by means of the prism reflector, can be concentrated so as to produce a flash-light of several hundred thousand candle-power.

In no branch of artificial illumination has so great a revolution been achieved during the past ten years as in oil-lighting. Whilst the cost of electric lighting has been reduced during this period, perhaps 50 per cent, and that of gas lighting 75 per cent to 80 per cent, the cost of oil lighting has fallen at least 90 per cent. The effect of this remarkable improvement has been to place that much despised illuminant, oil, in the front as a rival in brilliancy

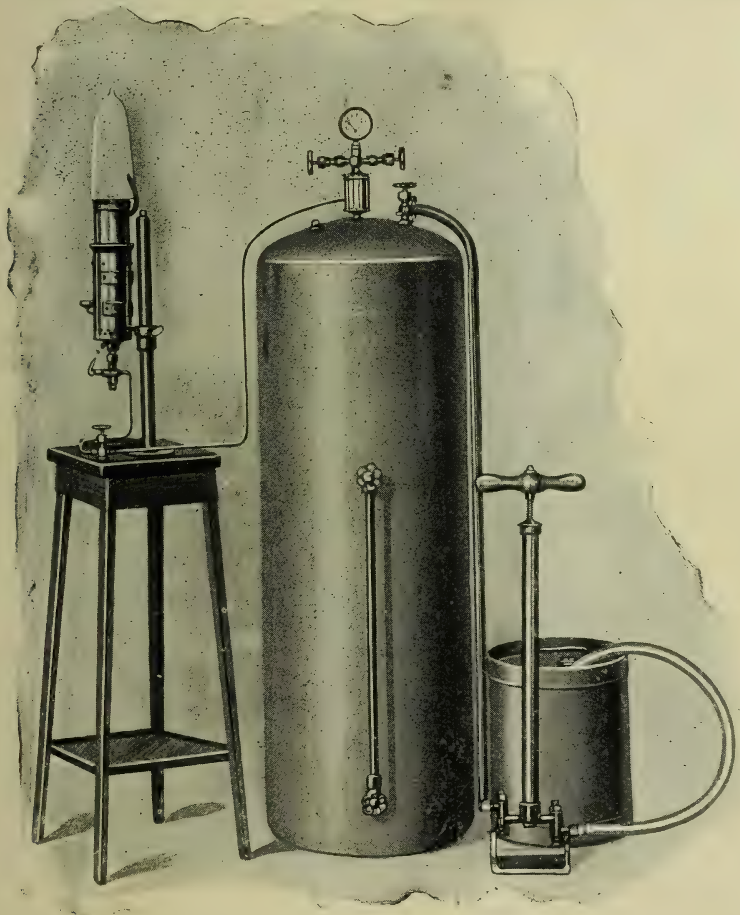


Fig. 2.
3,000 C.P. Lighthouse Installation, with Stand, 40-gallon Oil-tank Pump, Drum, and Fittings.

to the electric arc-light, whilst in cheapness it claims to outclass both electric and gas lighting.

Prof. Vivian Lewes, in his testimony before the Royal Commission on Coal Supplies, has quoted the relative cost per 1,000 candle-power hours as $1\frac{3}{4}d.$ in the case of high-pressure gas-lighting, and $1d.$ in the case of the Kitson light. The method, in fact, represents an important departure from the old wasteful "wick" methods of burning oil. It was in the year 1899 that the Trinity House authorities began to experiment with the incandescent oil-gas system, which was first applied to the Lowestoft High Lighthouse; since that date many other British lighthouses have been similarly equipped with the type termed the Matthews burner, which is

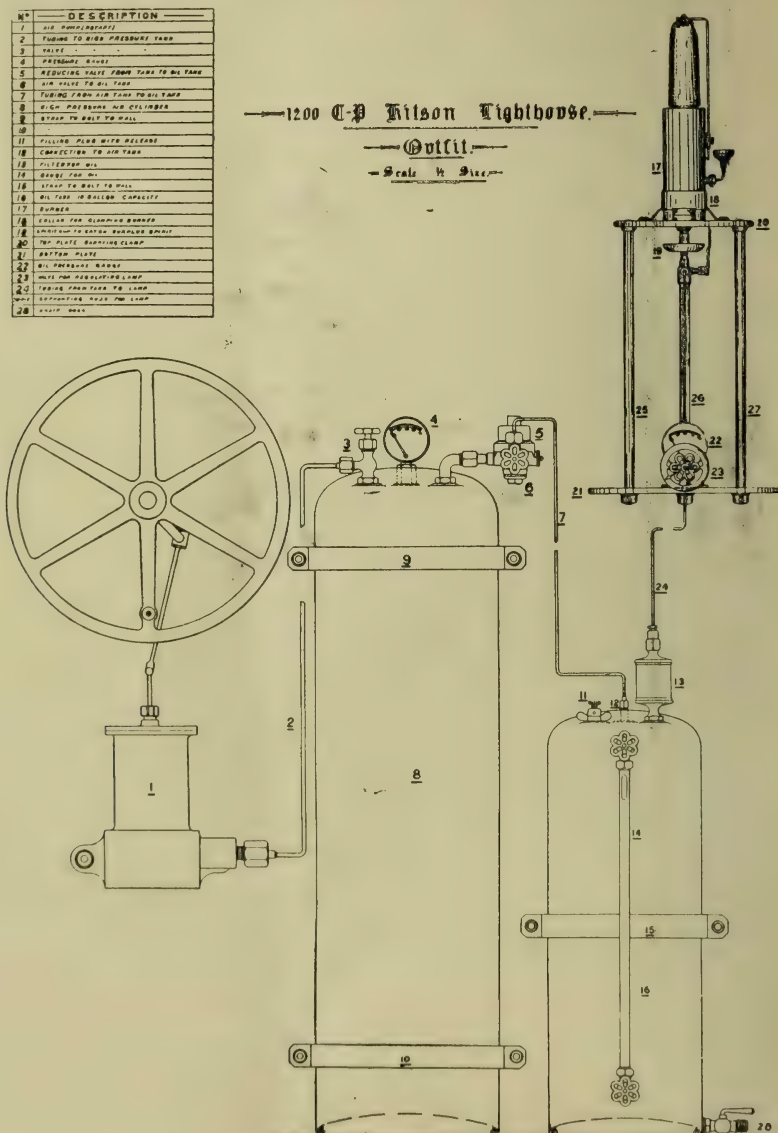


FIG. 3.

a lamp manufactured under the Kitson patents. The general nature of the installation utilized by the Trinity House authorities is shown in Fig. 1. A more recent example of an equipment for a lighthouse is shown in Fig. 2. It has an advantage over the Trinity House burner, in having no overhead obstruction, so that all the rays are concentrated and thrown on the reflector. The pressure on the oil-tank can be maintained either by the ordinary air-pump or by carbonic acid gas, both of which are furnished with this type of lamp.

In order to maintain a constant pressure upon the oil, two tanks may be employed, one for oil and one for air, and a regulating valve is placed between the two, so as to keep the pressure upon the oil constant at all times (see Fig. 3).

Such lamps can be started in one minute, and will run for 100 to 200 hours without further attention.

The Exhibition of the Physical Society.

THE fifth annual exhibition of electrical, optical, and physical apparatus, under the auspices of the Physical Society, was held at the Imperial College of Science on December 14th. Several demonstrations were arranged during the day, including some experiments by Prof. C. V. Boys on Soap-bubbles and a display of combinations of mica and selenite crystals by Professor S. P. Thompson.

In addition the exhibits included several items of interest dealing with photometry. Messrs. Elliott Bros., Ltd., exhibited the latest pattern of HARRISON PHOTOMETER, provided with both flicker and equality of brightness arrangements, enabling measurements to be made both in inclined planes and in the horizontal. This instrument has been described in previous numbers of this journal (*Illuminating Engineer*, vol. i. 1908, pp. 504, 1051).

Messrs. Everett, Edgcumbe & Co. also showed various types of photometers. The TROTTER UNIVERSAL ILLUMINATION PHOTOMETER was on view, and also the device, recently utilized by Mr. P. J. Waldram (see *Illuminating Engineer*, vol. i. 1908, p. 811), and originally devised by Mr. Trotter, which enables this instrument to be used for DAYLIGHT ILLUMINATION. The nature of this device will be recalled from the description in Mr. Waldram's article referred to above.

The arrangement has been used by Mr. Waldram for the study of the daylight conditions in many interiors in London.

The DIRECT READING PORTABLE PHOTOMETER, exhibited by the same firm is a self-contained arrangement intended for the rapid testing of carbon and metallic filament lamps. The arrangement is claimed to be exceptionally compact and to be capable of being used in broad daylight. It is utilized with a standard and a "comparison lamp" on the double weighing system. The distance of the lamp to be tested from the photometrical surface is virtually increased by the use of a series of mirrors, but by using the double weighing method the necessity for considering their coefficient of reflection is avoided. The adjustment of the intensity of illumination on the photometric surface is made by altering its inclination, the candle-power of the lamp being read on an experimentally obtained scale.

There was also exhibited a 10 ft. metal bench, provided with the Everett-Edgcumbe direct reading, adjustable screen photometer head, which can be used either as a "flicker" or as a comparison photometer.

There were also some other exhibits of interest from the standpoint of illumination. For instance the Weston Electrical Instrument Co. showed a portable wattmeter equipped with a

lampholder, to be utilized for THE COMPARISON OF CARBON FILAMENT AND METALLIC FILAMENT LAMPS, &c. A lamp of each type was provided to enable visitors to make this comparison. (It may be mentioned, by the way, that carbon filament lamps seemed to predominate in the portion of the building used for the exhibition.)

Another interesting exhibit was the MOUTH ILLUMINATING APPARATUS exhibited by Messrs. Carl Zeiss. This instrument is chiefly constructed to illuminate the interior of the mouth with an intense uniform light. An arc lamp is fitted at an angle to the condensing lens system, the latter being mounted in a conical tube. The condenser forms on the projection lens an image of the position crater of the arc lamp when the projection lens projects an image of the aperture of the condenser, five times magnified, at a distance of one metre.

Mention should also be made of the GAS-LEAKAGE INDICATOR of the Cambridge Scientific Instrument Co., Ltd. This is an ingenious application of the principle of the diffusion of gases. An elastic metal chamber is closed by a porous tile. When it is brought into an atmosphere charged with gas, the gaseous atoms diffuse through the porous tile with greater rapidity than the enclosed air passes out. The pressure in the chamber is thus temporarily increased, causing expansion, which is communicated by suitable mechanism to a dial pointer.

The same firm also exhibited several types of FERY PYROMETERS.

The Lithanode Co. exhibited different types of nonspillable and other type of accumulators, and also FORMS OF HANDLAMPS FOR MINES, &c.

Mention should also be made of the system of "ANTICLASTIC LEVERS" exhibited by Messrs. Strange & C. Graham, Ltd., as applied to models of flapping wing flight, collapsible boats, &c.

Conditions of space prevent our referring in detail to many other interesting exhibits less closely connected with illumination. Thus the Cambridge Scientific Instrument Co. also exhibited DUDDELL OSCILLOGRAPHS AND THERMO-GALVANOMETERS and ammeters, and DRYSDALE'S SLIP METER for the stroboscopic measurement of frequency and speed. A demonstration of the instantaneous PROJECTION OF **B** AND **H** CURVES by the Abraham Projection Rheograph was also given. Messrs. Casella & Co., A. C. Cossor, H. W. Cox & Co., J. H. Dallmeyer, Carl Zeiss Hilger, Ross & Co., and others, were responsible for the exhibition of scientific photographic and optical apparatus.

Messrs. Newton & Co. showed various types of GYROSCOPES, springs, pendulums, &c., and a collection of ELECTRICAL MEASURING AND TESTING APPARATUS of all kinds was exhibited by Messrs. Isenthal & Co., Muirhead & Co., Nalder Bros. & Thompson, R. W. Paul, Siemens Bros., Snell & Tinsley, in addition to Messrs. Elliott Bros., Everett Edgecumbe & Co., the Weston Electrical Instrument Co., and several of the firms previously mentioned in other connexions.

We may, perhaps, without wishing to appear ungracious, conclude this account of the display by a reference to one feature of the exhibition which, though not intended for examination in the same sense as the exhibits, is of special interest to us—namely, the lighting arrangements. The illumination was not always adequate, and we should think that the more liberal use of metallic filament lamps in the Imperial College of Science might be beneficial; it must be added that many of the fixtures employed are certainly open to improvement. For instance, unshaded naked lamps were almost invariably employed, and the object of certain transparent glass shades attached to some of the chandeliers is not very obvious; they certainly play no appreciable part in shading or directing the light. Also the permanent arrangements for the illumination of the main steps of the building seem to leave something to be desired.

The Progress of Illuminating Engineering in Europe.

By H. Thurston Owens.

A paper presented at the Third Annual Convention of the Illuminating Engineering Society, New York, Sept. 27, 28, 29, 1909; abbreviated.

The subject of illuminating engineering has been considered by the lighting engineers of Europe ever since the movement began in this country over three years ago, but did not become prominent until the London *Illuminating Engineer* was started on January 1st, 1908, by Mr. Leon Gaster, assisted by Mr. J. S. Dow.

The former had previously read two papers dealing with the subject which aroused considerable discussion, but the advent of the magazine proved that the subject was well worthy of attention, contributions from the foremost engineers, not only of England but of the Continent rapidly dispelling any doubts to the contrary.

One of the most significant events since the movement started was the fact that the privilege of delivering a series of the Cantor lectures on 'Modern Methods of Illumination' was conferred upon the editor of *The Illuminating Engineer*, Mr. Leon Gaster. These lectures are given before the Royal Society of Arts.

The British Illuminating Engineering Society.—About the time the lectures were delivered a dinner was held by the chief supporters of the movement, and the British Illuminating Engineering Society was organized (February 9th, 1909).

This was a remarkably short space of time considering the large number of societies which have found a home in London and the general apathy toward innovations along these lines among the engineers and scientists of our mother country.

It is the intention of the Society to become international in character and to work in harmony with this society. An important feature of the work undertaken is the large number of prominent men on the Continent and in America who have been elected corresponding members.

The Lighting Conditions.—The profession of illuminating engineering is still in its infancy abroad, just as it is with us; but the almost universal use of modern high powered illuminants has made it evident that the sooner the services of impartial practitioners are obtained the better. Yet the science of lighting has been handled for a much longer period, and some lamps which we term modern illuminants and have been hardly tried have become an old story with them.

To illustrate this more fully, let us consider the following. High-pressure upright gas lamps were installed for public lighting in Berlin less than ten years ago, but they are to be changed to the inverted type, as they have become obsolete; in this country neither type has been used at all except in one or two minor instances.

Flaming arc lamps will be found in practially every large city abroad, while this illuminant remains an advertising medium with us.

The lamps used for lighting our homes to-day were the lamps used for public ing yesterday, so that we may predict with fair accuracy that the lamps used to-day for public lighting will soon see their way into our buildings.

Street Lighting.—We have heard much of the superior street lighting to be found abroad, but nevertheless an American would have to be decidedly

blasé not to be forcibly struck by the profusion of lights and the high intensity of the illumination involved.

London is divided into a large number of boroughs, and each is apparently trying to outdo the other in providing the best street illumination possible, regardless of expense, with the result that there are all kinds and conditions of lamps hung in almost every conceivable manner.

The subject was recently investigated by a committee for the City of London, and their report is a valuable addition to lighting literature.

Outside lamps are very popular with storekeepers, and in a large number of instances hoods with transparent lettering are placed upon the street side, a practice which could be followed in this country to advantage.

Scheveningen, a summer resort in Holland, boasts a mile of flaming arcs along the ocean. These are installed upon handsome steel poles which would do credit to a metropolis.

[The author then proceeds to refer briefly to the lighting of various Continental cities, most of which are mentioned in the report of the London Corporation Deputation.]

General.—The principal differences between Europe and America in the minor details of the practice in public lighting are as follows :—

Circular or boulevard globes on gas lamps are unknown abroad, but the lack is made up by the use of reflectors, which we had entirely neglected.

Interior Lighting.—When comparing the lighting conditions abroad we must remember that the spirit of competition. between the greal illuminants gas and electricity is much keener there than at home.

In London one company alone maintains nearly 200,000 burners for consumers and in addition nearly 50,000 public lamps.

Gas is used for many purposes and in many instances which are given over to electricity in the majority of cases here. The result is that gas fixtures are an ornament rather than an eyesore. This is especially true in Germany, where art nouveau is in great favour, and rightly so, to judge from the beautiful effects obtained.

In glassware other than the very handsome installations we have not much to learn, as the new high efficiency lamps which have been used to replace the older types are as a rule somewhat larger in size and do not fit the old glassware.

The matter of maintenance receives much more care and attention than we bestow upon it, and broken mantles or dirty bulbs are the rarest exception.

The indictment against America on account of having sources of high candle-power in the line of vision must also be made against Europe, especially in the large cities.

Europe has anticipated us in the use of these modern lamps, but we have anticipated them by spreading a deeper and better understanding of their use and misuse.

It is indeed fortunate that illuminating engineering has made a strong foothold in this country, at a time in advance of the general use of light sources which are a great menace to our eyesight unless properly used.

We are making history in lighting to-day, and it behoves us to get together and make it worthy of our best efforts.

The old illuminants will soon be replaced by the new, and we as illuminating engineers have a magnificent opportunity to obtain for the present generation and the generation to come conditions which will not only tend to preserve our natural resources through the intelligent use of lighting appliances, but also to protect, and perhaps better, the vision of our fellow beings.

Electricity for Interior Lighting.

In a recent number of the *A.E.G. Zeitung*, to which we are indebted for the illustrations accompanying this article, Dr. L. Bloch writes on the applications of electric lighting to dwelling-houses from the æsthetic standpoint. A sharp distinction can be drawn between the so-called purely utilitarian aspects of illumination for office-lighting and so forth and the conditions which have to be considered in lighting an elegant interior.

There is, of course, no reason why the use of the more efficient lamps should not be equally conducive to artistic effects when rightly used. But there are several respects in which caution must be exercised. For instance, many of the old fittings intended for carbon filament lamps achieved their purpose quite well because the shades, &c., were so designed as to cover up the naked filament and diffuse the light. But when the longer metallic filament lamp is introduced it projects and looks unsightly even when not lighted—and still more so when burning, owing to the exposed metallic filament.

Fig. 1.—Room Lighted by Fixture containing Imitation "Electric Candles."

The design of the lights and fittings in the latter case opens out a field for useful effort on the part of the artist and the craftsman in ornamental metal-work. In particular we have to consider how to use the new metallic filament lamps so as to give us at once a good and pleasing illumination, and yet so as not to mar the dainty effects which have been achieved in existing fittings intended for the old carbon filament lamps.

However, progress in the direction of making metallic filament lamps with more dainty shapes of bulbs has been made. Several firms now supply 100-volt lamps with the filament packed away in the same size and shape of bulb which we have learned to associate with the carbon filament. Such lamps

can be satisfactorily used with existing shades. In addition spherical-shaped bulbs can often be used with advantage.

Another matter which is of urgent importance to consider is the added intrinsic brilliancy of the metallic filament. This has made it more essential than ever to screen the filament and diffuse the light, and this principle, Dr. Bloch suggests, rests both on a practical and on an artistic basis.

Ws must, therefore, make use of diffusing shades of frosted, opal, or cut glass, and Dr. Bloch makes special mention of the Holophane reflectors for use with fixtures of an ornamental variety. The style of fixtures intended for use with metallic filament lamps has been modified by the advisability of usually burning such lamps in a hanging position. The original necessity of adopting this plan, however, was not altogether a bad thing, because, as a rule, the proper diffusion of light is favoured thereby and there is less likelihood of any obstruction of the light. It may be regarded as a principle that, while taking the necessary precautions to avoid glare, we ought to avoid, as far as possible, any obstruction between the source of light and the object.

Although many of the higher voltage metallic filament lamps are still best burned in a hanging position, however, the same restriction does not apply to low voltage lamps, with a relatively low candle-power and stiff filaments. Lamps of this class are very readily utilized in the form of imitation candles and can be applied to old types of fittings intended for a cluster of wax candles, as shown in one of the illustrations (Fig. 2) on the opposite page. Fig. 1 also shows a room lighted with a fixture of this class Fig. 3 shows a fixture combining the candles in a vertical position with hanging lamps below. Figs. 4 and 5 display elegant types of fixtures with hanging lamps equipped with diffusing globes and reflectors respectively.

Another special department in interior lighting which has only received due attention of late years is the provision of portable and additional lamps for special purposes. Such lamps are exceedingly useful for reading, and for the dressing table, &c. In addition, electricity lends itself especially well to the local concentartion of lights for the pianoforte and for illuminating pictures and objects of special interest. Needless to say, this latter branch of illumination calls for special care and taste and offers a field for considerable ingenuity to those gifted with artistic instincts.

Cheap Terms for Porch Lighting.

In order to encourage the lighting-up of porches, &c., of private residences the Los Angeles Gas and Electric Co. have adopted a special system. They charge 70 cents a month for an 8 c.-p. light burning all night on the threshold of private residences. This is quite outside the ordinary lighting bill, and it is stated that many residents have taken advantage of the cheap terms to install such lights as a protection against burglars.

There is, however, another possible direction of utility of such lights. Most of us have at some period or other wasted a considerable time trying to find a house in some suburban street, owing to the fact that its name or number was absolutely indistinguishable in the dark. Probably any gas or electrical supply company that could take measures to encourage the adequate lighting of the names or numbers of villas so as to be easily discerned by a stranger to the district would earn the gratitude of many.

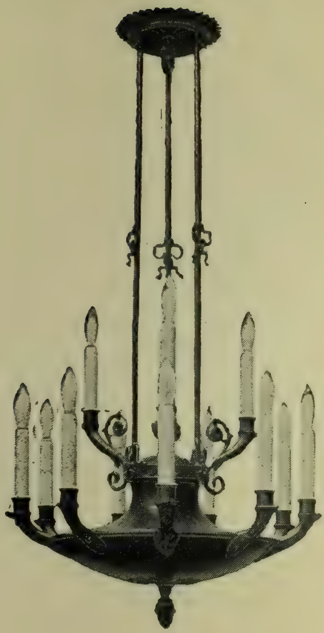


FIG. 2.

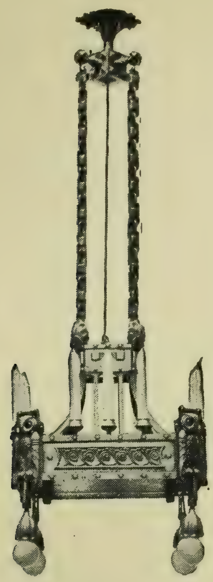


FIG. 3.

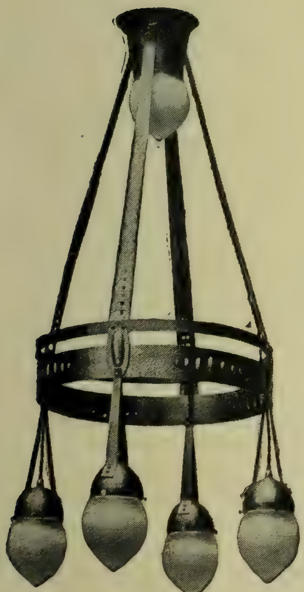


FIG. 4.

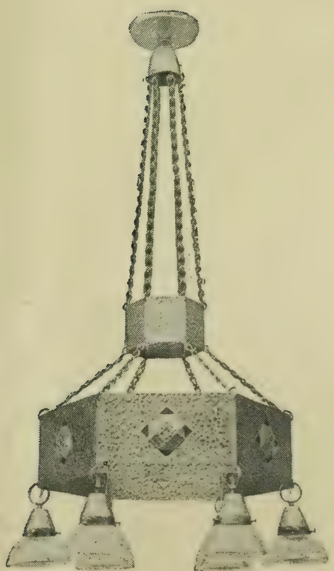


FIG. 5.

Types of Decorative Electric Fixtures.

Free Maintenance of Incandescent Mantles for Consumers —and other Matters.

A PAPER was recently delivered by Mr. H. N. Clark of West Ham at the Southern Association of Gas Engineers (see *Gas World*, Nov. 6), which raised several questions of considerable interest from the standpoint of the consumer. In view of the discussion which has been proceeding as to the treatment of consumers by electrical supply companies (see paper by Messrs. Handcock and Dykes, *Illum. Eng.*, Lond., December, p. 853) the consideration of the future attitude of gas companies will be followed with interest.

One matter which was the subject of much discussion was the policy of free maintenance. It was of course recognized, the speaker pointed out, that the inverted mantle constituted a more artistic and economical method of lighting than the old upright burner; at the same time it must be admitted that it was somewhat more difficult to manipulate. In Croydon, West Ham, and other districts the companies therefore introduced a scheme by which the company supplied new mantles of good quality for a reasonable sum, undertook attention to the burners and generally looked after the maintenance of the lights in proper order free of charge. However, it was admitted by the speaker that energy was still needed to make the great majority of consumers better acquainted with the merits of the scheme. For instance, in West Ham they were as yet only maintaining about 6 per cent of the existing installations, and the problem was how to secure the other 94 per cent of consumers. Some of the speakers in the discussion, however, were able to put forward somewhat more encouraging figures. Thus Mr. Price, of Hampton Wick, mentioned that 2,000 out of a total of 15,000 consumers had adopted the free maintenance system, and Mr. J. H. Cornish, of Bridgewater said that, in the small country town he represented 600 out of 1,330 consumers had fallen in with the suggestion,

Another matter to which reference was made was the effect of the policy on the local ironmonger, who at present frequently supplied both gas and electrical apparatus. Mr. Clark said that gas companies were willing to fall in with the position of the ironmongers as far as possible by making them agents. He added that it was desirable that ironmongers who contemplated doing business with gas and electric fittings should bear in mind the necessity of making themselves better acquainted with lighting problems. The supply of mantles by the Gas Company, moreover, had this advantage, that the consumer bought a good quality of mantle, though he might have to pay more than he would for a poor article purchased elsewhere, and, needless to say, the conditions of illumination enjoyed by the consumer were improved by the supervision of experts.

Mr. Clark also referred to the field open to gas in illuminated signs which had hitherto come to be regarded as opportunities for electric lighting. He also spoke of the supply of high pressure gas lighting for shops. In this connexion surprise was expressed by some present at the advocacy by the speaker of electric motors for the power supply, on the score of convenience and simplicity. This seems to be one direction where gas and electricity may sometimes work hand in hand.

One rather interesting statement of Mr. Clark was that in West Ham even educated people came to the showrooms asking to be supplied with electric lamps and fittings. They expressed much surprise when told that it was not the usual practice to supply one's opponent's goods. The author draws the conclusion that many consumers still require to be educated in the elementary distinctions between gas and electric lighting apparatus. Another conclusion which might perhaps be fitly drawn is the advantage enjoyed by the supply company which is concerned with the supply of both gas and electricity.

REVIEWS, ABSTRACTS, AND REPRODUCTIONS.

Scientific School Lighting.

(From *Holophane Illumination*, November, 1909; abbreviated.)

BOTH municipal authorities and the general public are becoming more and more alive to the fact that in justice to the children, the simple principles of good artificial illumination must not be neglected in lighting schoolrooms. For there are few schools which do not require a certain amount of artificial light, and many, during the winter months, are lighted artificially late in the afternoon nearly every day.

Many investigations in regard to the condition of eyesight in school children have been carried out recently both here and abroad.*

Moreover, the Vermont State Legislature, U.S.A., in 1905, began a study of the eyesight of children in the schools, and recent reports show that 34 per cent of these children were found to have defective vision. In New York, of 58,948 children recently examined, 17,938 or 30 per cent, were found to have defective vision. A circular issued by the United States Bureau of Information shows that near-sightedness steadily increases from class to class, until in the highest grades of the public schools as many as 60 to 70 per cent of children have defective eyesight. Many similar figures could be given, but the above are sufficient to show the importance of the subject. It is true, of course, that all defective eyesight cannot be attributed to poor artificial lighting, but the connexion is sufficiently evident to emphasize the necessity of paying great attention to proper illumination.

Some of the important causes of injurious effects due to improper lighting are as follows:—

1. Too little light.
2. Too much light.
3. Glare.
4. Undesirable shadows.
5. Regular reflection.
6. Streaks.

The first two of these causes can be eliminated of course by providing uniform illumination of correct intensity. The intensity generally accepted as desirable is from 2 to 3 foot-candles.

* For some figures on this subject see *Illuminating Engineer*, London, Vol. I., 1908, p. 58.

Glare probably causes more injurious effects than any other one evil in school-lighting systems. This is due to the fact that it is common practice to place light sources 6 ft. 6 in. to 7 ft. above the floor and to use reflectors or shades of such shape that the bare filament is practically within the range of vision. Figure 1 illustrates such an installation. Any attempt to see past these lights, as is necessary in looking at a black-board, causes considerable eye-strain.

Undesirable shadows are usually caused by the use of too few light-sources, or by placing the light sources too near the centre of the room. In a room 24 ft. square it is common to see four light-units arranged in the form of an eight-foot square in the centre of the room. This arrangement will not give satisfactory illumination on all the desks. In such a case, it is desirable to use more units, but if only four are supplied they should be placed more than 8 ft. apart in order to obtain sufficient light on the desks near the wall.

Regular reflection exhibits itself as a glare seen on a polished surface, such as the surface of a desk. It is eliminated by having the light come from the proper direction and by having light sources of low intrinsic brilliancy.

Streaks or striations in the illumination are caused by the unreflected light from a lamp or by light reflected from a very smooth or polished surface, such smooth opal or polished aluminium. These streaks cause the eye to try to accommodate itself to two intensities of illumination at the same time, an attempt which cannot fail to be harmful.

Several schemes using Holophane reflectors have been installed with satisfaction, and a number of these are given as examples of good school lighting. The standard schoolroom is approximately 24 ft. by 30 ft. to 32 ft. Very good results can be obtained by using five lights spaced as shown in Fig. 3. Each unit consists of either one 100-watt or one 60-watt bowl-frosted tungsten lamp and Holophane intensive reflector, the size of lamp depending upon the colour of ceiling and walls. It is highly desir-

able to have the reflectors satin finished, as this produces a much softer effect, and does not decrease the illumination more than a few per cent. The light units should be placed about 9 ft. 6 in. above the floor, and the resulting illumination will be somewhat over 2 foot-candles with 60-watt lamps when the ceiling and walls are both light in colour. In this connexion it should be stated that it is desirable to have ceiling and walls light in colour. The additional illumination received from reflected light is of great assistance in breaking up shadows and reducing their density. Holophane reflectors are of special value in this respect, since they are made of clear glass and the absorption is very low and nearly all the light

In large schoolrooms the same general scheme as given above can be carried out, using more light units. The directions for office-lighting as given in the May issue of *Holophane Illumination* can be successfully applied to large school-rooms. Schoolrooms differ from offices, however, in that the desks all face in one direction, making it possible to locate the light-units in such a way that the maximum light is always received from the left.

The illustrations, Figs. 1 and 2, show graphically the difference between the ordinary slip-shod installation of unscientific equipment and one laid out and equipped in strict accordance with the best engineering practice.

Fig. 1 shows a photograph of a schoolroom in Newark, N.J., lighted with

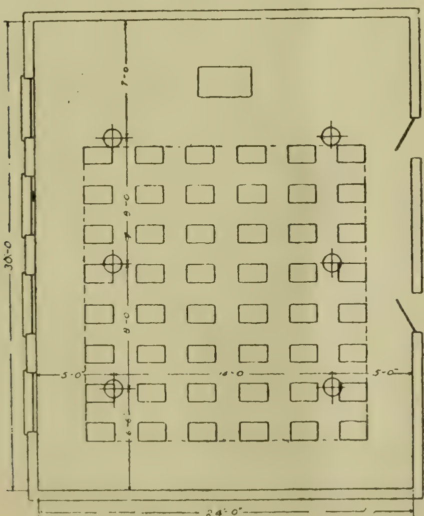


Fig. 3.

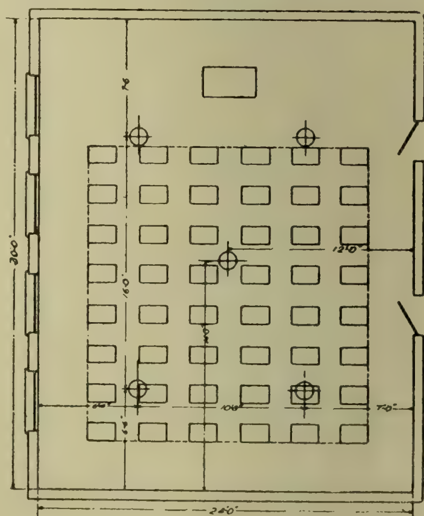


Fig. 4.

Figs. 3 and 4.—Plans showing Proper Locations of Outlets where Holophane Intensive Reflectors are used.

which is not directly reflected passes through and is redirected by the light ceiling and walls.

Another Holophane lighting system consists of using six light-units in the standard size schoolroom, these units being arranged as shown in Fig. 4. With 60-watt bowl-frosted tungsten lamps and satin finished intensive reflectors, with the light-units 9 ft. 3 in. above the floor, and the ceiling and walls light in colour, the illumination on the desks was found to be approximately 2·6 foot-candles. With nine 40-watt tungsten lamps and satin-finished intensive reflectors under similar conditions of ceiling and walls and with the lights 8 ft. 6 in. above the floor, approximately 2·5 foot-candles was the illumination on the desks.

carbon filament lamps and flat porcelain reflectors. Five fixtures were used, each containing four 16 c.-p. lamps. The total wattage was 1,120. Fig. 2 shows a photograph of a similar room in the same school lighted with 100-watt bowl-frosted tungsten lamps and Holophane enamelled reflectors. The total wattage was 500. Both these photographs were taken by the light of the light-units alone. In the room shown in Fig. 1, the bare lamp filaments, placed less than 7 ft. above the floor, were in the direct range of vision, and worked great injury to the eyes of the pupils. So satisfactory was the Holophane-tungsten lighting system found, that the same general scheme was adopted and is carried out throughout the schools in Newark.

FIG. 1.—Ordinary School Equipment (Newark, N.J., U.S.A.)

FIG. 2.—A room in the same school with Holophane Installation.

The Viscosity of Illuminating Oil.

By Dr. Ubbelhode.

(Abstracted from *The Petroleum Review.*)

Our readers may recall that in the first volume of *The Illuminating Engineer* (p. 244), we referred to some researches by M. Guiselin dealing with the effect of the level of oil in the reservoir of a lamp upon the illuminating value obtained. It was pointed out that consumers could benefit by frequently replenishing their lamps so as to keep the level high ; this improved value of the light obtained was, it seemed reasonable to suppose, to be ascribed to the fact that the oil had to travel a shorter distance up the wick and the capillary action of the latter was therefore assisted.

In this connexion some recent remarks by Dr. L. Ubbelhode, which are taken from *The Petroleum Review* may be of interest.

The essential condition of a kerosene lamp, he says, is to give a light of a constant illuminating power, which cannot be obtained without the flame being fed with a sufficient quantity of oil, the latter regularly and constantly ascending in the wick. The wick represents a large number of capillary tubes of irregular shape and size through which the oil ascends in the wick. The movement of the oil through the wick to the burner in which it is consumed is thus of a capillary nature, and is regulated by those forces which regulate all capillary movements of liquids, namely, by the surface tension and by the viscosity of the oil itself.

The surface tension of the illuminating oil is the force which is sending it up the wick, while the viscosity is a force producing resistance to the ascending movement of the oil. This antagonism of the two forces has been established first by Engler and Lisenko independently one of another, and later developed by Stepanoff, who in his work entitled 'The Theory of the Oil Lamp' has established the following formula: $M=\frac{a}{z}$, m being the quantity of oil ascended in the wick a the surface tension or capillarity and z the viscosity. The quantity of kerosene ascending the wick is thus in direct relation to the square of the capillarity and in inverse relation to the viscosity of the oil. As the capillarity of various lamp oils is practically the same, it is evident that the force of ascendency of a lamp oil in the wick depends entirely on the viscosity of the oil, and it must be of the utmost importance to have proper ways of comparing the viscosities of the various oils. The several viscometers do not show any remarkable differences in the viscosities of lamp oils and a new viscometer specially for determining these latter has been constructed on Engler's principle and has proved very useful in the study of lamp oils. The following table shows the viscosities of some lamp oils determined at 20° C. by means of the new apparatus, the viscosity of water at 20° C. being taken at unit.

	Specific gravity.	Viscosity at 20° C.
Benzine ...	0·7136 ...	6·692
Kerosene A.	0·8051 ...	1·109
,, B.	0·8053 ...	1·311
German ...	0·8129 ...	1·324
,, Cl. ...	0·7960 ...	1·436
Nobel ...	0·8201 ...	1·517
,, O. ...	0·8064 ...	1·586
,, E. ...	0·7963 ...	1·603
,, F. ...	0·8136 ...	1·801

As can be seen from the above table the specific gravity does not allow to draw any conclusions as to the viscosity of an oil, and that the quantity of a lamp oil ascending to a certain height in the wick is quite independent of its specific gravity.

Acetylene Lights for Air Ships.

A new opening for acetylene lighting has been commented upon in a recent number of *Acetylene*.

The airship, it is pointed out, is rapidly approaching a practical stage and will presumably require some type of head lights, of a powerful character. In addition the source must be as portable and self-contained as possible, and should be light and compact. It is suggested that acetylene lighting is specially adapted to meet these requirements.

Some Physiological Aspects of Illumination.

THE May number of *The Transactions of the Illuminating Engineering Society* in the United States contains several papers dealing with Physiological Aspects of Illumination, in which some questions of considerable interest are discussed. That by Prof. S. W. Ashe, for instance, deals mainly with the alteration of the pupil-aperture of the eye when exposed to sources of various intensities. In bright sunlight, for example, the diameter of the aperture was found to be 3·60 millimeters; in subdued daylight, on the other hand, it was slightly over 6 millimeters. The author also publishes a curve illustrating the variation in the diameter of the pupil-aperture of the eye at different parts of the spectrum, and at various illuminations. The maximum diameter appears to occur in the yellow-green portion of the spectrum, where the luminosity is generally believed to be the greatest. This, therefore, goes some distance towards suggesting that the opening of the pupil-aperture is controlled mainly by the intensity, and only to a less degree by the colour of the light to which it is subjected.

The author, however, has also compared the opening and shutting of the pupil-aperture for light of different colours. Briefly he finds that, for a given intensity of illumination, the iris-diaphragm closes less rapidly in the case of red light than when white light is used. The author also mentions that for the same luminosity he can read print at a greater distance when illuminated by light from the blue end of the spectrum than when illuminated by red; however, he also remarks that, irrespective of the intensity of the light, there seems to be a certain maximum reading distance further than which one could not read no matter how strongly the print was illuminated.

One of the most interesting contributions in the discussion of this paper was that of Mr. P. S. Millar, who drew attention to the fact, not alluded to in Mr. Ashe's papers, that it was not certain how far the inverse square law could be relied upon in the comparison of heterochromatic sources of light. Probably a distinctly different result could be obtained by using a flicker photometer, from that which would be obtained by using one of the ordinary variety. Indeed, Mr. Millar stated, "We know that, under some extreme conditions, two different kinds of flicker photometers do not give the same results with different observers." Mr. Ashe, too, mentions in his reply, that the correct setting of the Rood flicker photometer was found to be not always identical with that obtained by the aid of a judgment based on the equality of brightness pattern.

Another paper of some interest is that by Dr. W. L. Pyle. The author deals with the subject mainly from the standpoint of the oculist, explaining the different defects which occur in the eye lens, and which are popularly classified under the headings of long sight, short sight, and astigmatism. An important point insisted upon is that the visual apparatus must not be regarded as a separate organization, but as part of the general system of the human body. Anything which interfered with general bodily comfort was apt to be bad for the eyes. Some details of the method of testing effects of vision are also given.

The discussion initially turned on the effect of receiving the images of bright sources of light on the retina. Dr. Pyle stated that, under normal conditions, the eye can recuperate, but exceptional cases of long continued irritation, such as frequent exposure to the sun, might lead to permanent central scotoma, probably due to some chemical and physical change in the retinal elements in the eye.

The President, Mr. W. H. Gartley, refers to the question of indirect lighting, remarking that theoretically it might be considered desirable that all parts of the room should be lighted uniformly; yet the effect of complete uniformity is found to be unsatisfactory. It seems that the lack of contrast does not offer the eye sufficient opportunity for occasional adjustment, and does not satisfy its desire for occasional change. Dr. Pyle agrees that a room lighted in an absolutely uniform manner did produce a psychic impression of there not being sufficient light. The absence of the ordinary data as regards perspective and shadow is apt to oppress those in the room.

Mr. Gartley also refers to the effect of illumination on visual acuity, and suggests that it might be useful if oculists, in testing patients for visual effects, were to

record some details regarding the intensity of illumination. Dr. Pyle remarks that it is a common experience of oculists that different eyes respond in a very different manner to varying illumination —that is to say, a certain increase in the light available might lead to a greater improvement in vision in one case than in another. It is, however, rather outside the work of the ordinary busy oculist, and a rule ought to be done in physical laboratories where appropriate apparatus and observers with patience, time, and as training are available.

The Helion Lamp.

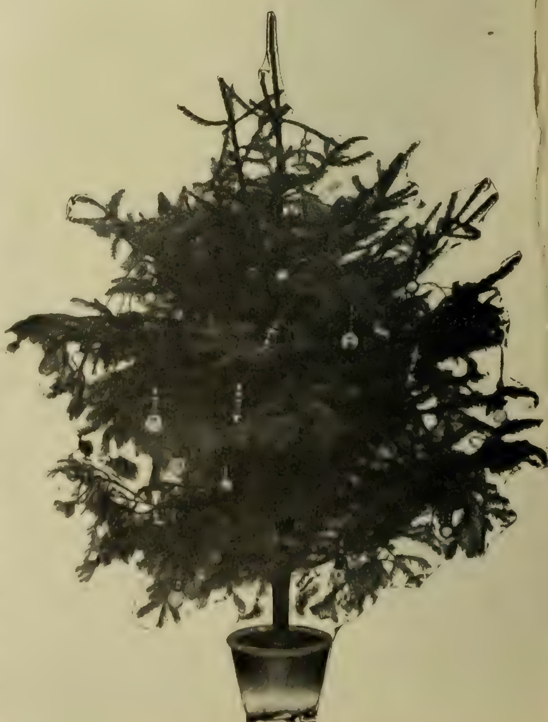
Announcement of the Parker Clark Electric Co.

The Parker Clark Electric Company announces the retirement of Mr. W. G. Clark from his connection with the Company and the election of Dr. George N. Millar to the offices of President and director. In order to be in close touch with their laboratories, the offices of the Company have been moved from the Singer Building to the Lincoln Square Building, 1966, Broadway.

The Company also state that the Helion Incandescent Lamp is now nearing perfection, and it is contemplated that the lamp will be offered to the public next spring. A special feature is said to be the Helion Naval lamp, which is specially contrived for use in the Navy and to withstand the shock of firing large guns on board of men-of-war. In addition to the fact that the filament itself is claimed to be exceptionally durable for its efficiency, the Company state that it will burn in the open air without apparent deterioration, in the event of the glass bulb being broken.

An Electrically Illuminated Christmas Tree.

An illustration accompanying this note shows the application of small metallic filament lamps to the lighting of Christmas trees. In view of the symbolic origin of the use of candles in this way, it is interesting to notice this substitution of the newer illuminant. Miniature glowlamps in various designs and colours are supplied in complete sets, the small filaments being wired in series, and the whole circuit plugged on to the mains. For instance, on 100-volt 9 candles in series are usually employed, and on 250-volt circuits 23 candles. For the use of this illustration we are indebted to the Electrical and Engineering Supplies Co., Ltd., 36, and 37, Upper Thames Street, London, E.C.



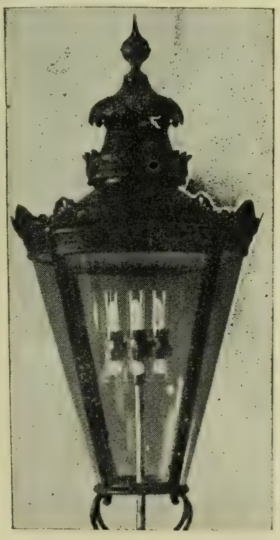
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

The "Twin-light" Burner.

The two accompanying illustrations refer to an interesting development in gas-lighting which was exhibited at the recent lecture on 'Modern Methods of Illumination' by Mr. L. Gaster at the London Institution. The arrangement in question consists essentially of two mantles, one upright and one inverted, which are mounted one above the other and fed by the same burner. We have received some particulars of this device from the manufacturers (**Twinlight Burners, Ltd.**, Wool Exchange, Coleman Street, London, E.C.), to whom we are also indebted for the illustrations accompanying this note.



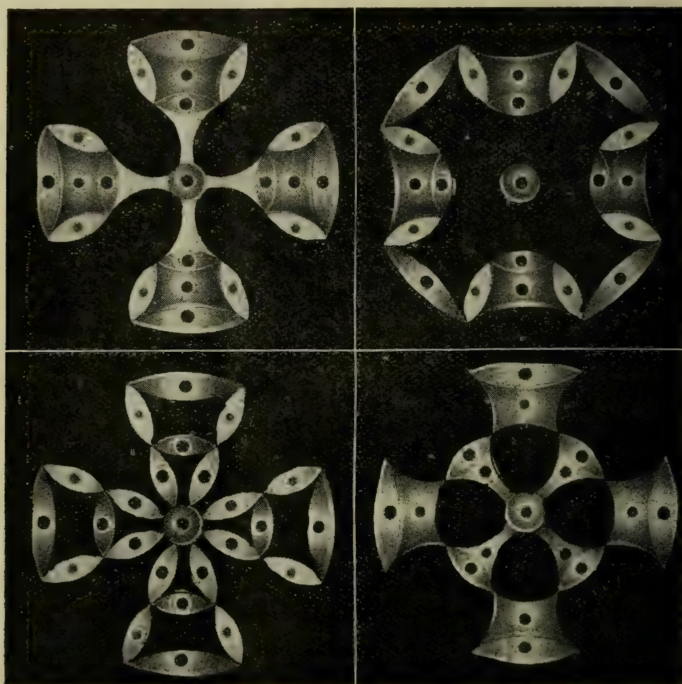
It is stated that only a slightly higher expenditure of gas than would be required for a single mantle serves to render both mantles fully luminous, the consumption on the usual two inches pressure being only about $5\frac{1}{2}$ cubic feet; yet only about one-fifth of the gas supplied is fed direct into the upper mantle, which, however, receives the products of combustion from the lower one. The arrangement is said to possess the main advantages of both types of mantles as regards distribution of light. Thus the inverted mantle is claimed to enable a strong downward intensity of illumination to be secured, while the upright is effectual in sending out light to illuminate the more remote regions of the roadway or pavement in a street. It is, indeed, anticipated that the combination of both mantles in a single lantern will be very effectual in certain cases, *e.g.*, street corners, &c., in which it is desired to improve the existing illumination without having resource to increased pressure.

The Chloride Electrical Storage Co., Ltd. (Clifton Junction, Manchester), send us a descriptive pamphlet of the "Entz" Booster.

Messrs. Verity's, Ltd. (31, King Street, Covent Garden, London, W.C.), send particulars of the "Aston" interpole motors.

The Kaleidoscopic Electric Sign.

THE accompanying illustration represents a new type of sign, brought out by **Messrs. Rashleigh, Phipps & Co.** (147, Oxford Street, London, W.). The essential characteristic of the sign is that the illuminated coloured surfaces are seen constantly changing, in the same manner as the well-known kaleidoscopic patterns formed by shaking bits of coloured glass.



A single sign is stated to be capable of automatically producing over 1,000 different designs, and it is also claimed that the sign, being self-contained and requiring no motor, has a distinct advantage over other types of flashing device in which some motor-arrangement is necessary.

Spookie Shades.

WE have received from **Messrs. Simplex Conduits, Ltd.** (113-117, Charing Cross Road, W.C.) some particulars regarding "Spookie" shades, some types of which are shown in Figs. 1, 2, 3, and 4.

These are examples of a variety of shade which is mainly used to screen lights of undesirable brilliancy, and to serve a decorative purpose. Illuminated by the light within, they give a touch of warmth to a room which it is sometimes desirable to secure by the use of a few illuminated tasteful coloured objects.

The shades are available in a wide range of colour, and they are stated to last well and "to give all the decorative effect of stained glass—but with an added richness and softness, and without the cold, hard lines that mar the beauty of a stained-glass shade."

FIG. 1.—Type of Decorative "Spookie Lamp Shade, for small lamps.

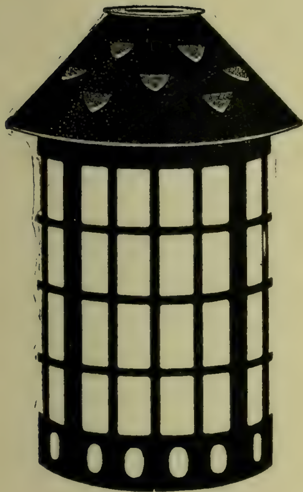


FIG. 3.—Ornamental Lantern.

FIG. 2.

FIG. 4.—Type of Decorative "Spookie" Lamp Shade.

Robertson Electric Lamps, Ltd.

ATHLETIC AND OTHER EVENTS.

SOME time ago we received particulars of the fourth annual sports of the above company. On this occasion, we note, the entries numbered over 400, and the list of events included a Marathon Race from Pinner to the ground at Shepherd's Bush; Mr. C. Wilson, Mr. C. J. Robertson, and Mr. E. G. Sheppard then officiated as judges, and the prizes were presented by Mr. C. Wilson.

We are now informed that as the result of the eleventh annual tournament of the London Private Fire Brigades Association, which was concluded on the 27th inst., at the headquarters of the London Rifle Brigade, Bunhill Row, E.C., the Robertson Electric Lamps, Ltd., Fire Brigade was successful in winning both the "Nestle" and "Marshall" Challenge Cups, and the "Dewar" Challenge Shield, the winning times constituting a record in any drills of this class.

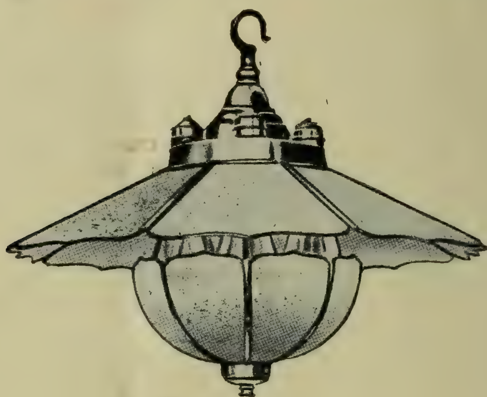
Finally, we note that on Saturday, December 11th, the second annual concert and distribution of trophies and medals took place, by kind permission of the directors, at the Brook Green works of the Robertson Company.

Concrete Lamp Posts.

THE type of lamp post shown in the accompanying illustration is being used in many of the residential districts of Washington, U.S.A., its peculiarity being that it is made of concrete. The columns are fluted and have an Ionic capital. They are placed 100 ft. apart on alternating sides of the street. Globes of frosted diffusing glass, clear glass, and so-called "rotten" glass are being experimented with.—*Popular Mechanics.*

Another Inverted Fitting.

We have several times called attention in these columns to the tendency to make more use of inverted systems of illumination now that powerful steady sources of light are available in the metallic filament high candle-power lamps. The ceiling may be utilised as the reflecting medium, but this is often undesirable either owing to its dark tint, or the liability of dust to accumulate, or for other reasons. In such cases, however, we may utilise what is equivalent to an artificial ceiling by providing the lamp with a matt reflecting surface on which the light is directed. In this way the glare, which is often a consequence of exposure of the eye to naked metallic filament lamps, is avoided.



An example of this method is shown in the accompanying figure representing the "Stationer" type of fitting supplied by the **General Electric Co., Ltd.** (71, Queen Victoria Street, E.C.). Here an opal glass reflector above, and a shade of similar material below, are utilised to mask the light, either four 50 candle-power or one 100 candle-power Osram lamps being usually employed.

Holophane Glassware.

In the last number of this Journal reference was made to a new catalogue of the Holophane Glass. **Messrs. Siemens Bros., Ltd.** (Tyssen Street, Dalston, London, N.E.) now draw our attention to their newly published list of Holophane glassware, which is supplied in conjunction with suitable clusters of tantalum lamps. We are informed that special supplies of this catalogue will be furnished to any bona-fide electrical dealer or contractor on receipt of an application in response to this notice, accompanied by a trade card.

Messrs. Siemens Bros., Ltd., also send us particulars of the Economic Electric Stove, having a stoneware body and expanded metal top, costing 19*s.* 6*d.* each. Polished aluminium combined radiators and stoves are also available at a price of 34*s.* 6*d.* complete. Supplied for voltage from 100 to 250.

Other Items.

We have also to acknowledge the receipt of particulars of :—

The Metallum colloid-tungsten incandescent lamps manufactured in accordance with patents developed by Dr. Kuzel, of Vienna, supplied by the **Brush Electrical Engineering Co., Ltd.** (106, Belvedere Road, London, S.E.).

"Metalik" Metal Filament Lamps (**Messrs. Boddy & Co.,** 15, Grays Inn Road, Holborn, London). These lamps are now stated to be manufactured as follows :—

16 candle-power, 10 to 130 volts, at 2*s.* 9*d.* each.

25 candle-power, 200 to 260 volts, at 4*s.* each.

The "Attracta" electric signs, and the "Chamberlain" Anti-Vibrator, for use with metal filaments (**The "Attracta" Electrical Co.,** 75, Fetter Lane, London, E.C.).

The Electrical Co. (121, Charing Cross Road, London, W.C.), motor starters and electric lighting accessories.

CORRESPONDENCE.

The Lummer-Brodhun Photometer.

DEAR SIR,—Mr. A. P. Trotter (*Illuminating Engineer*, vol. ii. p. 151) has kindly described the Lummer-Brodhun Photometer as "an ingenious system of prisms." But his added remark that the prismatic arrangement constructed by Prof. Brodhun and myself in 1889 (*Zeitschr. f. Inst.*, 1889, p. 41), had already been used by Prof. Weber in 1888 requires qualification. Immediately after our publication Messrs. Franz, Schmidt, and Haensch, who now make our photometer, built the prismatic arrangement into the Weber instrument, and they were able to do so because we, as officials at the Reichsanstalt, were not at liberty to patent it.

With regard to Mr. Trotter's humorous remark that "The telescope or microscope is considered to be an indispensible adjunct to any scientific instrument in Germany," and his additional comment that "To claim that in its most elaborate form it yields over three times the accuracy of a Bunsen photometer for lights of the same colour does not mean that it is three times as good as a Bunsen," &c.' I should only like to ask this question· Has Mr. Trotter really worked with our instrument; and did the Lummer-Brodhun photometer used by him, of which "the construction is so complicated; there are so many surfaces to keep clean, and such exact adjustment of the parts is necessary," &c., bear the words "Made in Germany"? The photometers constructed by Messrs. Franz, Schmidt, and Haensch (see *Zeitschr. f. Inst.*, 'Die photom. Apparate der Reichsanstalt für den technischen Gebrauch,' Feb., 1892), are protected against the effects of dirt. They are available either in the "equality of brightness" or "contrast" form, and, in spite of Mr. Trotter's objection to the "eye-piece," have found wide application both in this and other countries.

Believe me, &c.,

PROF. O. LUMMER,

Director d. Physik. Inst. d. Universität Breslau.

SIR,—In reply to Prof. Lummer, I have not "really worked" with a Lummer-Brodhum photometer, if this means carrying out any appreciable quantity of real work with it, but in preparing my articles I have visited many laboratories and lamp factories for the purpose of examining their photometrical equipment, and have always enquired about this photometer, and have frequently tried it. I have sometimes made a set of ten or fifteen observations for the purpose of ascertaining the mean deviation from the mean, and if I have not found that the precision to be obtained materially exceeded that of other instruments. I am fully aware that such casual tests are not of much importance. With photometers, more than perhaps any other instruments for physical measurements, it is necessary to become well accustomed to a particular pattern before good work can be done with it. I have not really worked with the Lummer-Brodhun instrument for three reasons. (1) I seldom have need to carry out ordinary tests of candle-power, most of my work having been in the direction of measurement of illumination and of research on the reflecting power of matt surfaces, and the dispersion of light by translucent substances; for this, special apparatus has been used. (2) I never begin work until about 9 p.m. and have to stop between 11 and 11.30 because I become too tired. I am quite sure that

the use of a Lummer-Brodhun photometer would reduce the quantity of work that I could do by more than one-half, on account of fatigue, and the gain in precision would not, for my purposes, be appreciable. (3) The instrument is expensive, and, I repeat, difficult to keep clean and in adjustment.

I have based my criticisms of it on the combined testimony of many persons. I find that if anything more than the mere dusting of the surfaces is needed, it is probably necessary to send the instrument back to Germany. I have not noticed the name of the makers. I did not know that there was more than one, or that differences were not due to improvements. I have now examined the interior of two instruments made by Messrs. Franz Schmidt & Haensch, and find that silvered mirrors are used instead of the pair of totally reflecting prisms shown in my illustration. If the faces of the prisms in optical contact be left out of account, there are only seven surfaces to be kept clean instead of eleven as I supposed. But after all, a little want of symmetry does not matter if the compensation or double weighing method can be used. My descriptions of photometers have been brief and intended for engineers rather than for physicists. I have implied, and I now state distinctly, that I believe there is no kind of photometer capable of higher precision of measurement than that of Lummer-Brodhun. I am, &c.,

A. P. Trotter.

London, Dec. 17, 1909.

A Central Technical Library and the Organized Collection of References to Technical Literature.

In a recent number we drew attention to the list of works connected with illumination published by the New York Library. We may also mention the work of the "Internationale Institut für Techno-Bibliographie" in Germany which has for its object the systematic arrangement and collection of papers on technical matters, patent literature, &c., in different countries. In addition, it is now proposed to form a Central Technical Library where all such material may be available. It is pointed out that although a number of libraries devoted to scientific and technical literature exist in Berlin and elsewhere they are usually connected with scientific technical colleges and institutions, and not always readily accessible to the general public.

In addition it is naturally to be expected that any single library of this kind should be more or less restricted to certain branches of technical work, while a central institution of the kind suggested could be made much more representative.

The Disaster at Hamburg.

It is with deep regret that we notice the terrible accident which occurred at the Hamburg Gasworks last month. The contents of a huge gasholder, which, we understand, was one of the largest of its kind in the world, somehow became ignited. As a result a number of people, at present estimated at nearly 50, were killed or seriously injured, and a large amount of valuable property was destroyed. It does not fall within our province to consider the conditions responsible for this accident, and it would perhaps be premature as yet to do so. But we feel bound to take this opportunity of expressing our deep concern at the calamity which the city of Hamburg has experienced, and our sincere sympathy with the relatives of those who have suffered.

Review of the Technical Press.

ILLUMINATION.

SEVERAL editorials in the gas and electric journals, in addition to those mentioned in the last review, discuss in favourable terms the inaugural meeting of the Illuminating Engineering Society in this country on Nov. 18th, 1909, and the Presidential Address delivered on this occasion.

A number of general articles on illumination have recently appeared in the United States; special attention may be directed to several in the December number of *The Illuminating Engineer* of New York, including that on SPECIFICATION FORMS FOR ILLUMINATING ENGINEERING AND WIRING SYMBOLS. This article shows how the lighting of many premises can be schemed out and expressed in terms of a tabular specification with appropriate symbols. **R. E. Scott,** in the same journal, deals with the ELECTRIC LIGHTING OF AUTOMOBILES.

Among other articles of a varied nature we may mention that of **J. Sumec,** who discusses the polar curve of light distribution of the Excello arc-lamp, with and without the dioptric globe. He finds that in the former case a post as inconveniently high as 23 metres would be desirable in order to get the best possible distribution of light; but when the dioptric globe is used, a post of about 11 metres will answer.

PHOTOMETRY.

SEVERAL articles deal with the FLICKER PHOTOMETER, and its physiological basis. Among these may be mentioned the contributions of **H. Morris Airey** and **S. W. Ashe,** and the discussion of a recent paper by **J. S. Dow.** All these articles refer to the theory of the rods and cones as a possible explanation of the action of the photometer. H. Morris Airey seeks to explain a possible inconsistency in the action of flicker and ordinary photometers, by supposing a different rate of dying away of the three primary colour sensations.

B. Monasch and **F. Laporte** discuss the present unit of the intensity of illumination, and point out the possibility of different interpretations of the meaning of the word "Lux." Monasch gives an amended table connecting units employed in different countries.

A lecture by **J. Abady** deals with the LAWS UNDERLYING PHOTOMETRY. The lecturer points out the limitation of these laws and comments upon the desirability of avoiding empirical measurements. Finally he describes a form of compact photometer in which the illumination of the photometer screen is adjusted by varying the extent of an illuminated area, instead of moving the source of light.

ELECTRIC LIGHTING.

Among articles of a general character we may note that by **Siegel** (*A.E.G. Zeitschr.*, Dec.), who deals with ELECTRICITY FOR CHURCH LIGHTING. Among the illustrations shown one observes a number of instances in which arc-lamps have been introduced into church interiors, a somewhat striking illustration of the modern added to the ancient.

G. Wilkinson and **R. MacCourt,** in a recent paper, deal with electric lamps and their effect on the lighting industry, special particulars being given of the methods adopted in Harrogate to avoid the danger of immediate reduction of revenue owing to the introduction of metallic filament lamps.

Among other articles touching electric lighting by glow-lamps we may note the description, in a recent number of *The Electrical World*, of LARGE ROOF SIGNS in New York, the account of some tests on metallic filament lamps in *The Electrical Engineer* (Dec. 3), and the article by **Henry,** which is reproduced in several French periodicals.

Several contributions have appeared dealing with arc-lamps. Chief among these is a very complete article by **P. Heyck** in the *Elektrotechnische Zeitschrift*, in which recent progress in the FLAME ARC-LAMPS of Messrs. Körting and Mathiesen is summarized. A number of polar curves of light-distribution of these lamps, both for direct and alternating current, and with various types of globes, are given. **W. S. Weedon** (*Elec. Rev.*, N.Y., Nov. 27) deals somewhat fully with the TITANIUM CARBIDE LAMP. He gives particulars of the rate of burning away of the electrodes, the characteristic curves of the arc, and the conditions controlling its steadiness, &c., and also a rather interesting polar curve, according to which the maximum intensity would seem to lie in a horizontal direction.

An interesting note in the *Journal für Gasbeleuchtung* deals with the work of the "Glühlampen-Einkaufsvereinigung des Verbandes Schweizerischer Elektrotechniker," a body which supervises the sale

of glow-lamps on a large scale in Switzerland. The tests undertaken are said to have proved very beneficial, and it is again stated that reliance can only be placed on "long-life" tests. Short life-tests, on the basis of overrunning by a given percentage of pressure, yield discordant results.

The Electrical World has also a short note on the use of the VACUUM TUBE LIGHTING IN SILK MILLS. It is said that the value of this source for matching colours has enabled many mills to carry on their work after dark by artificial light, whereas they would formerly have been compelled to stop the matching processes as soon as daylight failed.

GAS, OIL, ACETYLENE, LIGHTING, &c.

Several editorials in the English gas journals again deal with LEGISLATION ON GAS TESTING and the "Test Burner Bill."

McBeth in a recent paper before the American Gas Institute dwells on the desirability of A STANDARD SPECIFICATION FOR INCANDESCENT MANTLES; this is commented on in *The Illuminating Engineer* (New York).

A number of articles and papers in the American journals have dwelt upon the value of ILLUMINATING ENGINEERING FROM THE GAS STANDPOINT. Thus **Thompson** (*Prog. Age*, Nov. 15, *Am. Gaslight Jour.*, Dec. 20) insists on this point, and gives data for the lighting of various classes of shops, &c. The figures he quotes for the intensity of illumination desirable are probably higher than those prevailing in many shops in this country running up to 10 candle-feet for display windows.

M. Scholz (*J.f.G.*, Dec. 25) summarizes recent improvements with the Grätzin light. He dwells upon the value of the INVERTED MANTLE, both for interior and for street lighting. For the latter purpose, he points out, the mantle may be placed at a lower height than would be necessary in the case of flame arc-lamps, to secure the most favourable light-distribution between two successive lamps. A previous article by **Witt** in the same journal describes RAISING AND LOWERING ARRANGEMENTS for street gas lamps, and the method of suspending high-pressure gas lamps on wires crossing the street; to this reference is also made by Scholz.

Other articles deal with recent systems of automatic control of gaslamps; among these we may mention the continuation of the article on CHEMICAL IGNITING DEVICES in the *Zeitschrift für Beleuchtungswesen.* A recent number of the *Journal of Gaslighting* also refers to what seems an interesting development in mantles. This consists of forming a quartz core on which the incandescing material is deposited; it is claimed that the resulting mantle is very durable. **Lux** (*Z.f.B.*, Nov. 30) describes some researches on the BEST PROPORTIONS OF CERIUM in the mantle. This is generally believed to be about 0·8 per cent, but a new process, with the object of reducing the amount of cerium necessary, has been brought out. Lux, however, confirms the old result. Mantles containing 0·1 per cent and 0·8 per cent of cerium possess luminous efficiencies of 0·142 and 0·501 per cent respectively.

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Some Points in Relation to Arc Lamps (*Elec. Rev.*, Dec. 17).
A Lamp Removing Apparatus (*Elec. World*, N.Y., Nov. 18).
Shock Absorber for Tungsten Lamps (*Elec. World*, N.Y., Dec. 2).
The Vacuum Tube in Silk Mills (*Elec. World*, N.Y., Dec. 9).
The A.B.C. Flaming Arc (*L'Electricien*, Nov. 13).
Thousand Candle-Power Tungsten Lamps (*Elec. Engineer*, Dec. 3).
Metallic Filament Lamps (*Elec. World*, N.Y., Dec. 9).
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GAS, OIL, AND ACETYLENE LIGHTING, &c.

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Gas Legislation for 1910 (*G. W.*, Dec. 4).
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The Competition of High Pressure Gas (*Elec. Rev.*, N.Y., Dec. 4).
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Gaszündvorrichtungen (5), Chemisch wirkende Zünder (*Z. f. B.*, Nov. 30).
Churchlighting, by inverted gas burners (*G. W.*, Nov. 20).
The "Dacolight" Regenerative Lamps (*J. G. L.*, Dec. 7, *G. W.*, Dec. 18).
The "Dacolight" Controller (*G. W.*, Dec. 11).
Automatic Lighting of Public Lamps (*J. G. L.*, Dec. 14).
Incandescence Mantles (*J. G. L.*, Dec. 14).
Supports for Gas Lamps (*Am. Gaslight Jour.*, Nov. 22).
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CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
Prog. Age.—*Progressive Age.*
Phys. Rev.—*Physical Review.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

An Important Patent on Metallic Filament Glow-Lamps Declared Void.

A German correspondent informs us that one of the most important and interesting German patents, relating to the support of metallic filaments in glow-lamps, has recently been declared void by the German Patent Office.

The patent in question is specified in the application D. 16836 (filed March 14th, 1906, by the Deutsche Gasglühlicht A.G., opened to public inspection Aug. 19th, 1907, declared void Nov. 15th, 1909), which claims :—

Electric glow-lamps having metallic filaments provided with supports, not forming part of the electrical circuit, and characterized by the property that the sensitive ribs of which they consist are bent, to an extent visible to the naked eye, when subjected to the slightest strain ; these supports being intended to guard against the sagging or tearing away of the filament.

The German application is stated to be identical with the British Patent No. 6803 of 1906.

Some Publications Received during the past Month.*

Among the publications received during the past month we have to acknowledge with thanks the following :—

The Distribution of Gas. By Walter Hole. Second Edition. (Messrs. John Allen & Co., *The Gas World* Offices, 8, Bouverie Street, London, E.C.)

Transactions of the Institution of Gas Engineers for 1909.

Proceedings at the Twelfth Annual Meeting of the International Acetylene Association (*U.S.A.*).

Bulletin of the Bureau of Standards. (October, 1909.)

Atti della Associazone Elettrotecnica Italiana. (July—August, 1909.)

Arkiv för Matematik, Astronomi och Fysik. (Upsala and Stockholm.)

Bulletin de la Société Imperiale des Naturalistes de Moscou. (Russia).

Street Lighting. By E. N. Wrightington. (Paper presented at the Fifth Annual Meeting of the National Commercial Gas Association, Dec., 1909.)

* To some of these publications we hope to refer in greater detail shortly.

The ELECTRICITY · ACETYLENE · OIL · GAS
ILLUMINATING ENGINEER
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EDITORIAL.

Glare, its Causes and Effects.

THE meeting of the Illuminating Engineering Society on January 11th, at which this subject was brought forward, gave rise to a most interesting discussion, and the thanks of the Society are due to Dr. J. Herbert Parsons for the carefully thought out address by which he opened the proceedings.

Owing to the wideness of the subject it was found desirable to restrict the first evening's discussion mainly to the physiological and theoretical aspects, and to deal at the next meeting, to be held on February 15th, with the more familiar applications of these principles. This decision has also the advantage that it affords members an opportunity of examining the contributions of foreign authorities before the resumption of the discussion. We hope that full use will be made of this opportunity and that all those who cannot arrange to be present will communicate their views in writing, preferably before the next meeting, and in any case before February 20. The discussion of this subject will probably be concluded on this occasion, but those interested will have a further opportunity of participating in the discussion in our columns after this date, if they so desire.

A special acknowledgment is due to our corresponding members who have come forward and made such a valuable contribution to the discussion on this occasion; we think that readers will regard their efforts as an excellent illustration of the international importance of the work the society hopes to perform.

It is clear that physiologists in general recognise several distinct objectionable qualities of illuminants which are apt to be confused together as "glare." It is very desirable to discriminate between these different

effects since, as has often been seen, confusion in this respect is apt to engender partisan controversy on the subject of different forms of illuminants, and the putting forth of claims which, in the present state of knowledge, it is difficult either to confirm or refute.

We notice that several authorities point out the tendency to confuse the evil effects of excessive brilliancy with those connected with colour and wave-length. This the unlearned habitually do and it is often difficult to analyse even approximately what the "man in the street" means by describing a system of lighting as glaring. Occasionally we hear the expression "a nasty white glaring light," in which an objection to a white quality of light is confused with its intrinsic brilliancy. Among authorities, on the other hand, we sometimes find glare attributed mainly to the effects of ultra-violet rays, as distinct from visible light, but this, as Dr. Parsons points out, should be considered separately from the effect of excessive brightness.

On the whole, however, we find that experts seem to favour a definition of glare based on brightness and not colour. Yet even this by no means settles the scope for difference of opinion. We find for example that while most writers lay stress on intrinsic brilliancy pure and simple as the main factor to be considered, Prof. L. Weber considered that *contrast* and the difference in brightness between a source and its surroundings, is at least equally important. This view is again contested by Dr. Stockhausen, whose very careful and exhaustive study deserves special mention. Dr. Stockhausen, while recognizing that such severe contrast is a source of eye-fatigue, prefers to attribute this effect to rapid changes in retinal and pupillary adaptation which he apparently classes as quite distinct from the true "glare" effect, namely the exhaustion of the visual material in the retina by an excessively bright image.

Dr. Louis Bell, who takes a somewhat intermediate view, is inclined to agree with Prof. Weber that contrast between an illuminant and its surroundings is the most important point to be considered, and Dr. E. P. Hyde describes an experiment which leads him to suppose that the area of a luminous source is also an item to be borne in mind.

When we come to the questions as to how far the size of a luminous surface, its distance away, and other factors, as apart from intrinsic brilliancy, influence impression of glare, we find general agreement that further study is needed, and, while several possible but quite different methods of measuring glare are suggested, notably those of Dr. Voege, Dr. Stockhausen, and Dr. Krüss, we find that here, too, it is recognised that before any definite recommendation can be made much further study is needed; at present, however, several authorities agree that the study of the diameter of the pupil-aperture is a very uncertain test.

In the space at our disposal we can only briefly refer to a few of these interesting points. Our readers must study these communications for themselves. We think, however, that it will be recognised by the Society that this important matter cannot be decided in a few open discussions, however valuable such meetings may be as a means of enlisting support and drawing attention to the subject.

It may therefore be found desirable to appoint an international committee to deal with the matter.

Whatever view we take as to the nature of glare, we find general agreement that the most recent brilliant illuminants are often unwisely used, and that some steps should be taken to ascertain how far it is possible to devise practical recommendations to check this evil—and this will form a valuable piece of work to be performed by the Society.

The Importance of the Physiological Standpoint.

The above remarks lead us to comment briefly on one aspect of the matter which is not always fully appreciated, namely the need for explicit information regarding the physiological processes which go on in the eye, and their bearing on problems of illumination. For example, we sometimes hear a person expressing his views on this matter exhibit impatience with what he terms the "jargon" of the anatomist and the physiologist. We cannot help thinking that this impression, that experts in a certain line mystify a plain subject by "jargon," is almost always an indication of a somewhat narrow view. It is usually those who know least of a subject who are inclined to suppose that it is unnecessary to know more, and who insist upon the value of the "prosaic," or, as it is sometimes mistermed, commonsense view. What appears to the outsider to be "jargon" may be in reality scientific terminology, distinguishing and defining a number of different factors which the non-scientific man inaccurately "lumps together," under the head of glare.

Such information on the subject of glare as we have been able to collect in this number, only shows, as we have pointed out above, that there exist wide differences of opinion on really essential points in connection with the matter.

It is quite natural that, in the present state of things, there should be gaps in the physiologist's knowledge. They are the natural result of the fact that the eye has not been very fully studied from the standpoint of the effects of illumination upon it, but chiefly with a view to discovering structural deformities. Now, however, that these new aspects are being brought home to the expert who is really in a position to deal with them we may expect to see the desired information gradually acquired. In this connexion we may anticipate the experience of the oculist and ophthalmic surgeon may be very helpful in confirming suggestions of a theoretical nature regarding the effect of light on eyesight.

It cannot too often be insisted that all impressions of illumination and lighting are received through the eye and that it is therefore to the study of the eye that we must go for the fullest information as to how our systems of illumination should be contrived. If an investigation into such questions is to be of value at all it must be *thorough*. We must get right down to the root of things, sift the many inconsistent views by which we are at present bewildered, and ascertain what differences in terminology are responsible for misunderstanding. If we do not do this, and if our recommendations are based on nothing better than a hasty generalisation on imperfect knowledge, we cannot expect them to carry the necessary weight. The desired results can only be obtained, we repeat once more, by concerted action between all the different experts concerned and the physiologist is, in this case, in a position to render specially valuable assistance.

The Risk of Fire due to Careless Methods of Illuminating Shop-Windows.

During the past month public attention has been directed to several more or less serious fires originating in show-windows of various premises, in which electric lights had been assembled to give an extra display. A specially distressing instance was that which occurred at Messrs. Arding & Hobbs's at Clapham, where the premises were practically destroyed and a number of people unfortunately either lost their lives or were seriously injured.

As usual the technical press has been busy commenting on the subject and, in some instances, has fallen into the usual rut of endeavouring to prove that the accident furnished an illus-

tration of the invariable risk attaching to electric light, and the safer qualities of gaslight or *vice versa*. Needless to say we do not desire to follow on these familiar lines. Yet we think that accidents of this nature should lead to one obvious but not always sufficiently appreciated conclusion, namely, that any illuminant becomes a source of danger, when it is abused.

Authorities on illumination have for some years been pointing out the absurdity and uselessness of the system of placing bright sources of light among the goods in the window in such a way as to dazzle the eyes of those looking in. Recent experience has only served to show that this system, besides being most objectionable from the illumination standpoint, may be positively dangerous. Electric light, on account of its very convenience of manipulation, is specially liable to abuse in this way.

It is hardly necessaiy to add that in the case of decorative and display lighting, where certain efforts towards effectiveness are sometimes coupled with some concession in the way of risk, every care should be taken to make sure that the workmanship and material are of a thoroughly reliable character. But in addition we think it may well be adopted as a maxim by shop-keepers that the actual sources should be kept away from the goods they are intended to illuminate, and, if possible, out of the direct range of vision as well. By so doing they will at least approach the system of illumination most favourable for the purpose of displaying the goods, and they will also eliminate what is now recognized to be a possible source of danger.

We understand that there is some possibility of regulation being introduced by the London County Council affecting the objectionable practice of placing sources of light among the goods. If we may make a suggestion we should like to see also inserted in such regulations some reference to the fully-justified condemnation of such systems, on the ground of their effect on eyesight. The City have already taken action demanding the screening of glaring powerful lamps hung at a low level outside shops, and we think that something on similar lines might well be done to check the reckless use of bright sources in windows. Besides the danger of sudden conflagration there is also the slow and, therefore, not so readily recognized effect of such sources on eyesight to be guarded against, and we cannot see that the practice in question has anything to recommend it even from the purely commercial standpoint.

Anniversary Dinner of the Illuminating Engineering Society

On p. 132 in this number readers will find an intimation of the dinner which has been arranged to take place on Feb. 10th, just a year since the origination of the Society in this country.

Looking back we have every reason to congratulate ourselves on the progress since that date, but we now need every effort on the part of members to consolidate still further the position of the Society. It is anticipated that this dinner, besides providing members in different parts of the country with an opportunity of meeting and knowing one another, will lead others to take an interest in its doings and increase its membership and influence.

We hope, therefore, that members will make a special effort to be present and to bring with them friends likely to be interested. In addition we need scarcely add that any of our friends in foreign lands who may find it possible to join us will be very heartily welcome.

Leon Gaster.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 79) continue his description of the Everett Edgcumbe form of Trotter Illumination Photometer. He refers to the value of a scale of incidence angles, and makes some comments on the battery, switch, and contacts, which, owing to the low voltage employed, require special care. In conclusion he discusses the correct height of the photometer and gives two curves illustrating the results obtained with the instrument at heights of 4 ft. and 1 ft. from the ground.

Dr. W. W. Coblentz commences his paper on the Distribution of Energy in the Spectrum of Illuminants (p. 83). He begins by explaining what is meant by the theoretical "black body," and also the "gray body." The latter conception, he suggests, is misleading, because it is difficult to find any material the radiation of which exceeds the radiation of a black body in the same ratio throughout the entire spectrum. We always find that there is some degree of "selective" action. The author also presents radiation-curves of various insulating and metallic materials which illustrate his remarks on the theory of radiation from such substances.

Mr. P. J. Waldram deals with the Measurement of Illumination from the Standpoint of the Architect (p. 89). He points out that the conditions of daylight and artificial illumination in interiors have a marked effect on its architectural appearance, and how vague and unsatisfactory are the present records available. For instance there is much misunderstanding as to the influence on the intensity of daylight illumination of different qualities of sky. Finally, the author advocates much closer study of these matters from the standpoint of the architect.

Dr. C. P. Steinmetz (p. 93) deals with the Physiological Aspects of Radiation. He points out the possibility of different qualities, both of visible and invisible radiation, producing peculiar effects, but lays stress on the influence on the retina of high concentration of energy of any description. This he terms a "power blow," the effect being to burn the retina locally. A different effect is produced by the ultraviolet rays, but these again must be distinguished from one another and classified. Those of smallest wave-length are most harmful.

Following this article is a brief account of the meeting of the Illuminating Engineering Society on January 11th, when the subject of "**Glare, its Causes and Effects**" was discussed (p. 97). The discussion was opened by **Dr. J. Herbert Parsons, F.R.C.S.,** whose address will be found on p. 99. Dr. Parsons points out that the sensation of glare must be studied in the light of the physiological processes which go on in the retina; therefore, one of the most important factors is retinal adaptation. Thus a person coming out of a dark room, with a "dark-adapted" retina is very sensitive to light. Anything affecting the sharpness and clearness of the retinal image might also be classed as glare; the direct reflection from the printed page might be so termed. Dr. Parsons also refers to the ultra violet rays; these, however, exert a special effect which should, strictly speaking, be distinguished from ordinary glare. In addition, it is probable that glare, properly defined, is a function of luminosity rather than colour.

In the subsequent discussion **Dr. Edridge Green** (p. 103) refers to the important part played by personal peculiarities. For example, his own eye is exceptionally sensitive to ultra-violet light. Some eyes possess different powers of adaptation from others, and

what one person might consider glare another would not find objectionable. This might be ascribed to a difference in the retinal pigment. **Dr. F. Gans** refers mainly to SNOWBLINDNESS, which has been ascribed by many to the effect of the ultra-violet rays. Yet it is difficult to distinguish what is due to this cause and what to the visible **Dr. Ettles** refers mainly to the effect of reflected light within the cornea in affecting the clearness of the retinal image; in this way excess of light would be harmful. **Dr. J. Kerr** points out that a number of varieties of "glare" exist. For example, the glare due to excessive intrinsic brilliancy is to be distinguished from that caused by light entering the eye from the wrong direction, as is apt to happen in consequence of badly placed prismatic window-glass. **Dr. T. M. Legge** refers to the effect of ultra-violet light in causing cataract, and to the need for keeping within limits the brilliancy of illuminated signs.

Following this discussion will be found the communicated remarks of **Mr. P. J. Waldram** and **Dr. W. Bayliss.** The former comments on the difference in the conditions prevailing by artificial and daylight illumination. In the latter case the eye seems to be able to bear a much stronger degree of illumination without flinching. Dr. Bayliss agrees as to the necessity for screening bright sources of light placed within the range of vision and also defines glare as mainly a matter of intrinsic brilliancy.

A variety of COMMUNICATIONS FROM CORRESPONDING MEMBERS of the Society follow. These are naturally too extensive to be dealt with at all adequately in abstract. **Dr. Stockhausen** contributes a very exhaustive analysis of glare from the physiological standpoint (p. 109). He terms an illuminant glaring when its image is so intense that the "upper limit of adaptation" of the eye is exceeded, and the visual material is used up quicker than it can recuperate. He also discusses the other factors besides intrinsic brilliancy which affect the problem, gives a complete table containing the figures for the intrinsic brilliancy of a large number of sources of light, and proposes a method of studying glare based on "after-images."

Dr. Corsepius replies briefly to the series of queries on glare and gives an instance of the system of illumination adopted in the Engineering Schools of Cologne to avoid it.

Dr. L. Bell considers that *contrast* between an illuminant and its surroundings is the most potent factor in producing glare. He also refers to the injurious effects of excessive glare on traffic. **Dr. E. P. Hyde** describes an experiment illustrating the effect on the eye of altering the size of the bright surface examined.

Dr. H. Seabrook and **Dr. E. O. Sisson** enter into the physiological processes taking place in the retina and the effect of ultra-violet rays, &c.

Prof. L. Weber dwells chiefly on the effect of excessive contrast and gives a table of intrinsic brilliancy in primary and secondary units. **Dr. L. Bloch** makes a number of suggestions regarding the effect of bright lights in practice and the possible methods of avoiding glare in interiors and street-lighting. **Prof. R. Ulbricht** gives some figures for the maximum permissible brilliancy and points out that this depends on the purpose to which a room is put. **M. Lauriol** thinks that theoretically the permissible glare is zero, but in practice we must compromise. **Prof. S. Rumi** terms glare mainly the result of excessive intrinsic brilliancy, and gives some practical rules for its avoidance. **Prof. Strache** and **Mr. Prenger** allude to the effect of excessively bright lamps hung low down outside shops, &c. **Dr. H. Krüss** and **Dr. W. Voege** describe methods of testing glare based on photometry and photography respectively.

At the end of this journal will also be found some CORRESPONDENCE by **Dr. L. Bloch** and **Mr. Codman** regarding methods of determining M. Sph. C.P. from the polar curve of light-distribution and a letter from **Dr. H. Krüss** on the LUMMER BRODHUN PHOTOMETER.

On p. 135 will be found the TRADE NOTES and on p. 141 the REVIEW OF THE TECHNICAL PRESS.

TECHNICAL SECTION.

[*The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'*

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement,

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p. 10, Vol. III.*)

Scale of Angles of Incidence, and Its Uses.—The outside view of the instrument given in Fig. 106 shows a graduated quadrant, and at the centre from which this is struck, a little pin is provided. This acts as a style or gnomon, its shadow falling on the quadrant enables the angle of incidence of the light of any lamp to be read. In addition to this a circular spirit level is let into the top, flush with the case. In some instruments I have added a scale of cosines, for facilitating candle-power measurements.

Reference to Table I., page 185, vol. i.; or to Fig. 13, page 271; or to Fig. 43, page 625, vol. i., will show that at a point midway between two lamps placed at a distance apart equal to six times their height, the angle of incidence is about $71\frac{1}{2}$, and the illumination due to each lamp is only about 0·03 of the maximum (assuming uniform candle-power in all directions). Practical measurements of illumination cannot usefully be carried further than this. At these large angles of incidence, the photometer must be carefully levelled. A difference of 10 per cent in the illumination of the screen is made by a difference of one degree of level from 79 to 80, or by two degress from 69 to 71, or by three degrees from 60 to 63. Besides these theoretical errors, which can be read off direct on a slide-rule, there is probably a distinct departure from the cosine law with all practicable materials for the screen. On the other hand illuminations below 0·05 foot-candle are not of great importance in themselves, and errors in their measurement are not of much consequence.

Measurement of Candle-Power.—Following on the lines laid down by Sir W. Preece in 1883* my early work was confined to the photometry of illumination, and that, on a horizontal plane. I rarely measured candle-power. The public and the street lighting authorities are concerned only with illumination, but the engineer and contractor who has to supply the illumination has to consider candle-power as well.

To measure candle-power with an illumination photometer, the first step must be to find the vertical height of the lamp above the ground. To obtain this, set the photometer at such a distance from the lamp that the shadow of the pin falls on 45°; the case being level. Measure the horizontal distance from the lamp to the pin, and from the pin to the ground. The sum of these is the actual height of the lamp. This can be measured without difficulty to about 2 per cent., say 3 in. in 12 ft. 6 in.

* "We do not want to know so much the intensity of the light emitted by a particular lamp as the intensity of the illumination of......the surface of the streets and of the pavements...... we want to know in fact the degree of illumination due to the emitted light, not the intensity of the rays of the source of light."

Preece. Report to the Commissioners of Sewers of the City of London, 1884.

The limited range of angles possible by setting the photometer at different distances does not admit of a complete measurement of hemispherical candle-

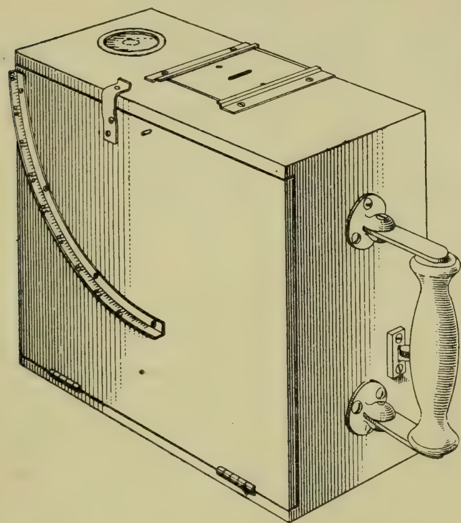

FIG. 106.—General view of outside of Everett-Edgcumbe instrument.

power, but it comprises most of the useful candle-power emitted. With a horizontal photometer the calculation is as follows :—In Fig. 107 H is the height of the lamp, h the horizontal height of the photometer screen from the ground, and D the horizontal distance of the screen from the lamp. $L = [H - h] \;/\; \cos\theta$ or $L = \sqrt{D^2 - (H - h)^2}$, and the candle-power is $(E \times L^2) / \cos\theta$, where E is the illumination in foot-candles.

It may be observed that when the square of the slant height L in feet is equal to the cosine of the angle of incidence, the scale graduated in foot-candles becomes a scale of candle-power, and when the square of the distance in feet is 10, or 100, or 1,000 times the cosine, the multipliers 10, 100, or 1,000 may be used to convert it into a scale of candle-power. The square of the slant height being known, the photometer may be tilted until the required cosine is indicated on the quadrant by the shadow of the pin. If the slant height is measured by the sum of the squares of the horizontal distance and the height, the square is at once obtained.

The pivoted mounting of the Everett-Edgcumbe pattern allows the photometer screen to be set exactly facing the lamp to be measured. This eliminates the cosine factor, and the illumination in foot-candles multiplied by the square of the distance in feet from the photometer to the light, gives the candle-power.

The Battery, Switch, and Contacts.—A two-cell accumulator supplying a four-volt lamp is used in connection with the photometer. Even an inveterate anti-motorist must admit that we owe to the modern motor-car the development of excellent portable accumulators. Transparent celluloid cells are best, for the free liberation of gas which indicates the completion of the charging can be seen. Some cells contain floats which roughly indicate the state of the charge. When fully charged, a pair of cells gives about 4·1 volts, but if left running at the normal rate of discharge for 10 to 15 minutes they settle down to a steady pressure. This depends on the rate of discharge and on the internal resistance. It is very nearly 4 volts. The capacity in ampere-hours at the normal rate is generally marked on the cells, and this should never be exceeded, but it is not likely to be reached in a long evening's work if the lamp is not used except when a measurement is being made.

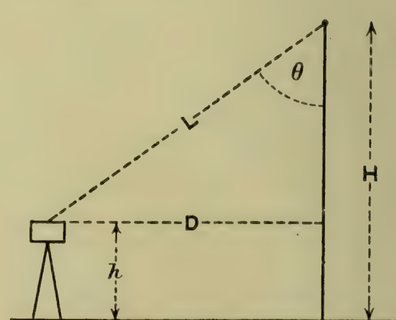

FIG. 107.

With so small an electric pressure as 4 volts, the slightest imperfection of contact makes a serious difference in the current. The use of bayonet or loop

contacts for the lamp is out of the question. A screw socket is good if it is well screwed home, but soldered connections are better. In my earlier

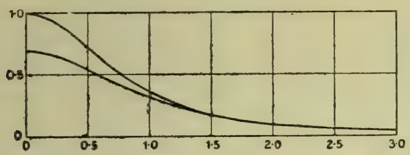

FIG. 108.

photometers the accumulators were carried in the instrument, but Messrs. Everett, Edgcumbe & Co. provide a separate accumulator and flexible conductors. If these wires are carefully used and inspected, no error need arise. The instrument is more portable if the accumulators can be carried with one hand and the photometer in the other, but it is better not to disconnect them at all except for charging. The terminals of the accumulator must be clean and well screwed up.

The switch is a likely place for a bad contact. There is a great temptation to use a switch which lights up the lamp when it is depressed, and flies up with a spring when it is released. This, of course, prevents the wasteful running of the accumulator, but if the contacts are loose enough to allow the switch to fly off, it is very likely that they will not give exactly the same degree of contact every time. This can be tried during the check test which should precede every evening's work, and which should be repeated if possible at its close.

The weight of Messrs. Everett, Edgcumbe & Co.'s pattern is only 4 lbs.; the accumulator weighs 6 lbs., and a tripod as light as $1\frac{1}{2}$ lbs. can be provided. It is perhaps unwise to use a flimsy tripod. One with a shelf to carry the accumulator stands more firmly, and reduces the chance of a general wreck by an accidental entanglement with the flexible wires in street work.

Height of the Photometer.—With the exception of the instrument illustrated in Fig. 91, page 657, in my early work I always placed the photometer on the ground. This seemed to be the obvious way of measuring the illumination received by streets and pavements. The photometers with eye-pieces, such as the Mascart, Weber, and most modern continental instruments, on the other hand, have, naturally, been used on stands at a height of about $1\frac{1}{2}$ metres. In recent work in this country with my photometer and that of Mr. Haydn Harrison, a stand has been used, and the usual height of the photometer screen is from 3 ft. 6 in. (1·060 m.) to 4 ft. (1·22 m.) from the ground. Most workers prefer to keep the screen at some distance from the eye, in order to obtain a good general view of it.

The effect of the height of the instrument on the illumination received by it is easily calculated for a theoretical case in which the candle-power of the lamp is uniform in all directions. Let the lamp be 19 ft. from the ground, and the photometer screen, in one case 1 ft., and in the other 4 ft., from the ground. The lamp will then be 18 ft. or 15 ft. above the screen when the instrument is placed immediately beneath. The illumination in the latter case will be $15^2/18^2$ or 0·695 of that in the former. This appears at first sight to be a serious matter. Fig. 108 shows the curves of distribution of illumination in the two cases. The upper one having a maximum ordinate of unity represents the case of the photometer 4 ft. from the ground. This is

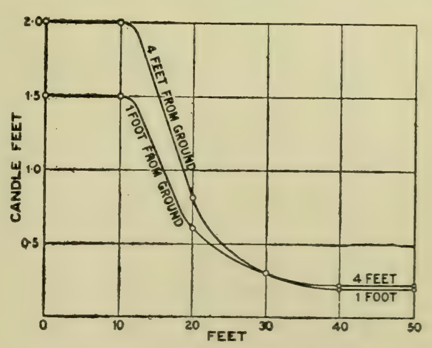

FIG. 109.

simply the cosine cubed curve which appeared so often in the theoretical section of these articles with the convention that the lamp is at unit height.

In the lower curve which represents the illumination on the screen when it is 1 ft. from the ground, this convention is not retained, and it will not be retained when we come to practical examples of measurement of illumination. The two curves rapidly approach and cross at a distance equal to about 1·5 times the height of the lamp. (See pp. 624, 625.) After crossing they lie at a distance apart which is less than the thickness of the line in the diagram. When the screen is 4 ft. from the ground, and the angle of incidence is 70°, the illumination is 0·400 of the maximum. When the screen is dropped to 1 ft. from the ground, the angle of incidence is 66° 24′, and the illumination is 0·0445. Although the slant height of the lamp is greater, the smaller angle of incidence more than compensates for it.

The difference seen on the left-hand side of the diagram loses its importance when the comparatively small area of horizontal surface over which this difference exists is taken into account. It may, therefore, be assumed that the height of the photometer has very little effect on the mean illumination; the difference as regards minimum illumination is imperceptible, and the height need only be considered when measurements are being taken beneath a lamp.

When the candle-power of the lamp is not the same in all directions, measurements of illumination at various heights will be affected somewhat differently. Fig. 109 gives the results of two sets of measurements made by Mr. Roger T. Smith at Paddington Station, G.W.R.

(*To be continued.*)

The Chemistry of Flames and Combustion.

In our last number some editorial remarks were made regarding the number of lectures which have recently been delivered dealing with various aspects of illumination. To these must be added the series of Juvenile Lectures which Prof. H. B. Dixon has just completed before the Royal Society of Arts. Prof. Dixon contrived to be both instructive and entertaining. He described the results of men like Cavendish, Sir Humphrey Davy, and Faraday, and illustrated his remarks with a series of experiments bringing out the nature of combustion of different gases, the luminosity of fine particles, the conditions under which a mixture of gases tends to become explosive, &c.

At the present time, when the theory of the bunsen burner and the incandescent mantle offer such an excellent field for investigation and discovery, the study of the properties of flame is a fascinating subject.

Modern Electric Illumination.

As explained in our last number, the final lecture of the course for juveniles delivered by Mr. W. Duddell, F.R.S., at the Royal Institution this winter, dealt specially with electric lighting. Mr. Duddell contrived to cover a great deal of ground in the time at his disposal. He traced the development of arc lamps and the electrical glow lamp and referred briefly to vapour-tube illumination. Further, he passed on to the importance of studying the use and distribution of light besides its production, and laid special stress on the need for exact methods of measuring light. Measurements of this kind, he suggested, must go hand-in-hand with attempts to utilize light scientifically.

It was not enough to have discovered how to use electricity so much more successfully for the manufacture of light. We must also study how to use it wisely, and reap the benefit of the improvements that have been made.

The Distribution of Energy in the Spectra of Commercial Illuminants.

By W. W. Coblentz.

(The following paper has been kindly presented by Dr. W. Coblentz, of the Bureau of Standards, Washington, U.S.A., as a communication for discussion at the hands of The Illuminating Engineering Society. The paper is an exceptionally exhaustive one, and will be continued in subsequent numbers of this journal. It is hoped that a special opportunity for discussion will be provided when this paper has been concluded. Meantime we shall be glad to receive any communicated remarks on the subject, which we will subsequently submit to Dr. Coblentz for final comment.—Ed.)

In view of the great activity in the attempts to improve our illuminants, it is of interest to summarize, in a general way, our knowledge of the spectral radiation of various substances used in lighting devices; for the luminous efficiency is, to a great extent, dependent upon the relative proportions of heat and light waves which are emitted. Much has been written on the so-called "selective emission" as a means of increasing the luminous efficiency of our light sources; but, as will be seen from the illustrations given on subsequent pages, various other factors in addition to selective emission enter into this question. Indeed, it appears that, whether the spectral radiation is in the form of a smooth continuous curve as in the metals, or whether the emitted energy is concentrated into sharp emission bands, as in the vacuum tube radiation, the production of light by thermal excitation is always accompanied by an appreciable amount of radiant heat. Thus far it has not been possible to avoid this heat production, and probably it never will be until we learn some of the secrets of the fire-fly, and of the manner of exciting fluorescence. Definitions and improbable conceptions of spectral energy partition will be useless in solving this problem. Kirchhoff's conception of an ideal radiator for all wave-lengths, which in turn is an ideal absorber, *i.e.*, one that has no reflectivity, has served an excellent purpose. By definition, the ideal radiator, at any temperature, must emit energy to the fullest extent for all wave-lengths throughout the spectrum. In practice we must content ourselves with a uniformly heated enclosure or "black body" as the nearest approach to the ideal one.

"Gray Bodies."

In marked contrast with Kirchhoff's ideal radiator, the "gray body"* does not appeal to one as being of great utility in theory or in practical work. If a body had a constant absorptivity for all wake-lengths it would be a "perfectly gray body," and its radiation would be, for all wave-lengths, proportional to that of a "perfectly black body." But the introduction of this form of analysis seems an unnecessary encumberance in our nomenclature, because of the improbability of finding a substance which emits an exact ratio of the intensity of a "black body" at all wave-lengths.

A concrete example of a "gray body" and of "gray radiation" would be the

* See Preston's 'Heat,' last ed., p. 590; and Guillaume, *Bull. Soc. Internat. des Electriciens*, 5. p. 397, 1905. The latter shows that the "gray body," originally proposed by Stefan, is too simple, for every radiating surface possesses, at every temperature and at every wave-length, a definite emissivity, which can have all values from 0 to 1.

radiation from a uniformly heated cavity ("black body") after it has passed through a rotating sector, or has been transmitted through or reflected from a substance (if such a substance can exist) having uniform transmissivity or reflectivity throughout the entire spectrum. In this manner all the radiation would be reduced by a definite and uniform amount, at every wave-length, throughout the entire spectrum.

From our present knowledge of the physical properties of substances, it appears as though all substances will be found to have selective emission in some parts of the spectrum. To analyze this radiation into its components, stating that so much is due to selectivity and so much is "gray radiation," seems impracticable for it is admitted that at any one temperature we may have an infinite number of "gray bodies."

All substances have a definite bounding surface which possesses a characteristic reflectivity, in contrast with Kirchoff's ideal radiator, which has no reflectivity, *i.e.*, one which absorbs completely all radiation falling upon it, whatever the wave-length, and hence emits completely energy of all wave-lengths. Since the emissivity, absorptivity and reflectivity of a substance are intimately related, we can gain some information as to the nature of its emissivity (whether "gray" or "black") from a knowledge of either of the other two properties. In dealing with substances of which the absorptivity and reflectivity are unknown we can compare them with chemically related substances; for it has been abundantly proven that the great groups of chemically related substances possess definite and similar characteristics. These substances are of two kinds, viz., insulators or "transparent media," and electrical conductors. The transparent media are characterized by a low reflectivity, 4 to 5 per cent, usually decreasing with increase in wave-length, which often extends far into the infra-red. These substances have narrow bands of selective absorption alternating with regions of great transparency (the reflectivity being but slightly greater than in the adjacent region). Beyond 7 μ ($\mu \div 0{\cdot}001$ mm.) they have regions where the absorption co-efficient suddenly assumes large values. In fact, as will be noticed in Fig. 1, which gives the reflectivity of several metals and

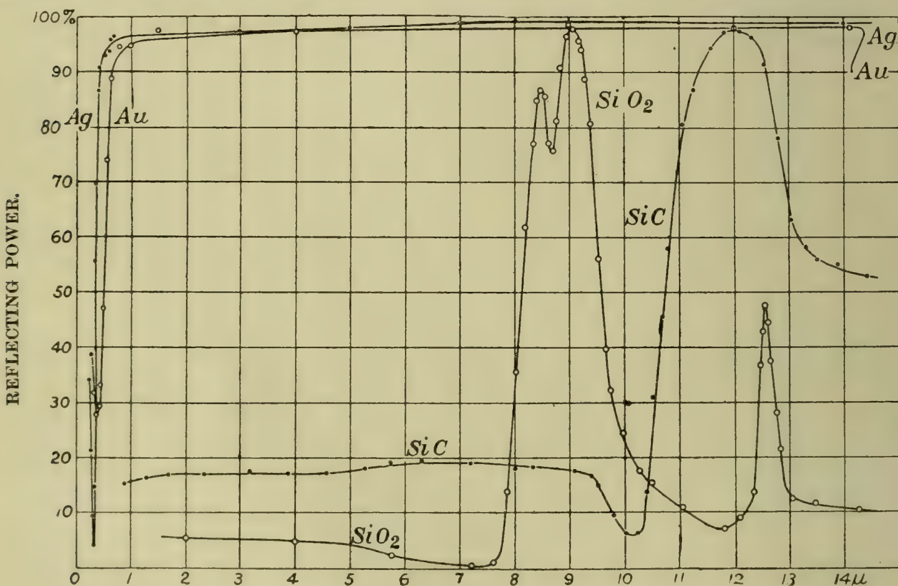

FIG. 1.—"Reflectivity" of various Metallic and Insulating Bodies.

insulators, the absorption coefficient assumes such large values that the substance reflects like a metal. This is well illustrated in quartz, Si O_2, and low reflectivity, and the whole is a region of anomalous dispersion. These conditions prevail throughout the spectrum from the ultra-violet to the

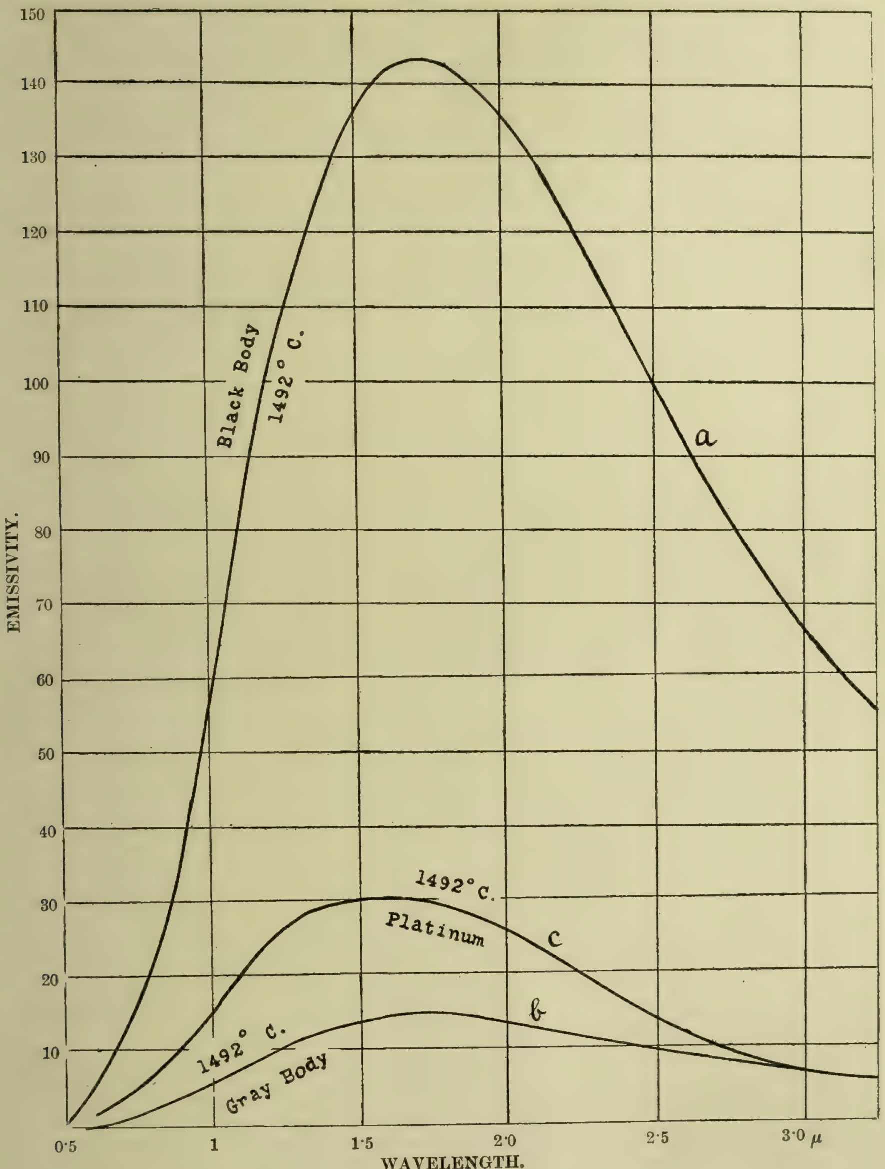

FIG. 2.—Radiation Curves of Gray Body, Black Body, and Platinum.

carborundum, Si C, Fig. 1. Immediately preceding these bands of high reflectivity (called metallic reflection) the substance shows an abnormally extreme infra-red, even for electrical waves. Out of the great number of substances already examined, covering all the great groups of chemically

related compounds, only one, viz., silver chloride, has yet been found which has no bands of metallic reflection; but even in this substance such a band is suspected in the remote infra-red. Its capacity is greater in the short wave-lengths than in the infra-red, and hence it can not emit "gray radiation." From theory and from experimental knowledge it is highly improbable that a "gray body" will be found among insulators. Even the various forms of carbon fail to conform to a uniform absorptivity over a wide range of the spectrum.

Turning now to the electrical conductors, we find conditions exactly the reverse of those in the insulators. In the metals the ionization is more complete. The absorption ("extinction") coefficient has high values throughout the infra-red and the narrow band (or bands) or metallic reflection, so characteristic of the insulators, is broadened out into a continuous disturbance extending from the remotest infra-red down into the visible spectrum. (See Fig. 1, which gives the reflectivity of gold and silver). The region of abnormally low reflectivity, *e.g.*, the one in quartz at 7 μ, is shifted into the ultra-violet in silver. Incidentally it may be noticed that quartz is one of the best insulators while silver is the best of electrical conductors. Observations show that (just the opposite to insulators) metals increase in reflectivity with wave-length and that for the long heat-waves the reflectivity is proportional to the electrical conductivity. This has been found true of all metals examined, which cover the whole range of the Mendelejeff series, and, in view of the fact that related groups of elements and compounds have been found to exhibit similar physical phenomena, there is sufficient reason to believe that the few uninvestigated metals, *e.g.*, tungsten, tantalum, osmium, &c., will have similar characteristics. It, therefore, appears safe to assume that among the electrical conductors as among the insulators, no substance will be found satisfying the condition for emitting "gray radiation," for here again the absorption (1 — Reflectivity) is not uniform throughout the whole spectrum, and the "gray body" is a myth. Since, at any temperature, we may have an infinite number of gray bodies differing only in the total amounts of radiation (Hyde *et alia.*, N.Y. Section, Illuminating Eng. Soc., Feb., 1909; *Electrical World*, liii. p. 439, 1909), the introduction of the "gray body" is an innovation which cannot be of real service in problems in radiation; but, with other similar conceptions, will more likely befog what little we know of the physical principles involved. In this respect it differs from Kirchhoff's ideal radiator, in which the *emissivity is independent of the composition of the radiating enclosure.* Furthermore, since the reflectivity of metals is uniformly increasing (*i.e.*, the reflectivity curve shows no indentations) throughout the infra-red, they cannot have bands of selective emission in this region of the spectrum. Their selective emission must occur in the region of the visible spectrum for all the metals, thus far examined, have a low reflectivity in this part of the spectrum. The coloured metals exhibit bands of selective emission, *e.g.*, a molten bead of copper in a Bunsen flame appears greenish, while molten silver is bluish in colour. In the "white metals," *e.g.*, platinum (to which class tungsten and tantalum seem to belong) the selective emission is in the form of a wide band extending over the visible spectrum. This is apparent from the fact that at any wave-length, $E = e\ (1 - R)$ where E and e are the respective emissivities of the metal and of the "black body," and R is the reflectivity of the metal.

In Fig. 2 is given the observed spectral energy curve, *a*, of a "black body," at a temperature of 1492° C., and that of a radiator "gray body" curve *b*, which has a uniform reflectivity of 90 per cent. (hence an emissivity of 10 per cent. of black body) throughout the spectrum. Curve *c* gives the emissivity of platinum. The area between the curves *b* and *c* gives the selectivity of platinum, which decreases as we proceed into the infra-red. The radiation curve of platinum is computed from the reflectivity

observed at room temperature, hence is not quite correct, since the reflectivity, like the electrical conductivity, has a temperature coefficient. These curves are plotted to the same scale, and the extraordinary difference in their emissivity at once becomes apparent. Platinum has a reflectivity of about 90 per cent at 3·5 to 4 μ, which increases gradually to about 96 per cent at 14 μ; hence its radiation is "gray," with respect to this particular "gray body" (curve *b*, Fig. 2) at 3·5 to 4 μ.

The insulators, if in sufficient thickness are far better radiators than the metals. The reflectivity is so low that they approximate very closely the black body radiation. The manner in which the spectral emissivity of a substance is decreased with increase in its reflectivity is shown in Fig. 3. The continuous curves represent the radiation from an ideal radiator at respectively 300° Abs. and 400° Abs. The dotted curves represent the emissivity of quartz (see Fig. 1) at the same temperature. In the region of selective reflection, at 8 to 9 μ (see Fig. 1) the emissivity is suppressed in proportion to the reflectivity. This was experimentally verified by Rosenthal and by Coblentz.[1]

Since the maximum spectral radiation of the earth occurs in the region of 8 to 10 μ and since the constituents of its crust are chiefly silicates, it appears that the earth cannot cool so rapidly as it would if there was no such suppression of radiation of wavelengths 8 to 10 μ. It is of interest to note that in the region of 7·8 μ, in quartz, the reflectivity is almost zero, so that (since the absorption is high) even for an ordinary thickness, the emissivity is practically equal that of Kirchhoff's ideal radiator. In fact, only in the region of anomalous dispersion can a material substance have this property, and the problem in illumination is to produce a radiator with a high melting point and having optical properties in every respect like silver (Fig. 1) except that the band of low reflectivity falls within the centre of the visible spectrum. Unfortunately all the "white" metals, *e.g.*, platinum, have their lowest reflectivity in the ultra-violet, so that we cannot get the full benefit of its selective emission. In addition to a higher operating temperature, it seems quite certain that tungsten and osmium owe their high luminous efficiency to strong selective emission, due to a low reflectivity in the visible and utra-violet part of the spectrum. Thus far the writer has been utterly unable to

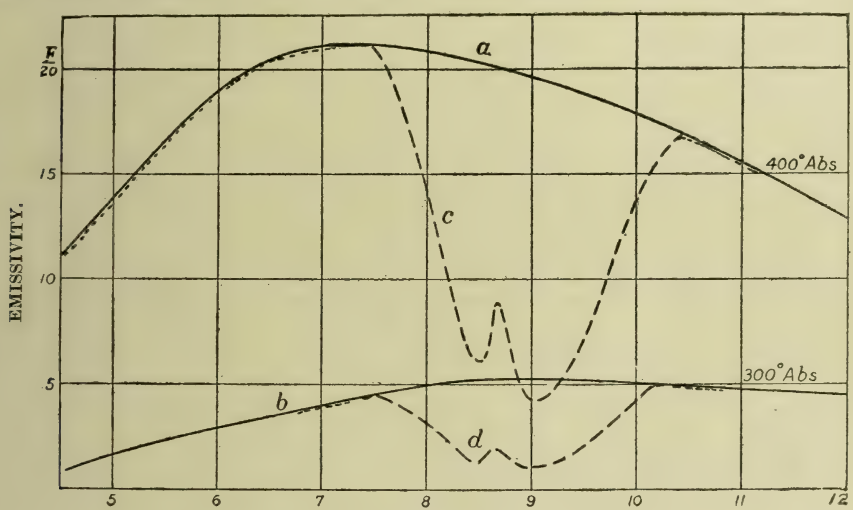

FIG. 3.—Change of Emissivity with Temperature.

[1] Rosenthal. Ann. der Physik (3) 68, p. 783, 1899. Coblentz, Bull. Bur. Standards, Vol. 5, p. 177.

procure mirror surfaces of these two metals to test this question, which is an important one in radiation. Curves showing the distribution of energy in the spectra of metals have been given in previous numbers of this journal[2]; and attention was called to the fact that a high electrical conductivity was accompanied by a high reflectivity (consequently low emissivity) in the infra-red. This seems to be a property of metallic (electrical) conductors.

[2] Coblentz, *Illuminating Engineer*, London, Vol. II., 1909, p. 557.

(*To be continued.*)

IIme Congres International des Maladies Professionnelles.

Study of Illumination and Defects of Vision.

By the kindness of Dr. T. M. Legge, H.M. Medical Inspector of Factories, we have received some particulars of the second meeting of the above international Congress, which is announced to take place, under the patronage of the Belgian Government, in Brussels on September 10th to 14th, and we understand that a very influential committee of organization has been formed.

A point of considerable interest to this journal is the fact that on this occasion a special section has been devoted to matters connected with eyesight and illumination. Thus the official summary of matters to be dealt with in the fourth section is as follows :—

> **L'œil et la vision dans leurs rapports avec les maladies professionelles.** L'éclairage rationnel des ateliers. Les procédés photométriques. Le surmenage oculaire. L'acuité visuelle pendant l'apprentissage. La cataracte et l'arc sénile des verriers et des ouvriers exposés aux rayonnements intenses. Le nystagmus des houilleurs. L'œil saturnin. Les lésions oculaires du sulfo-carbonisme. Les opthalmies dues aux poussières, aux gaz, aux vapeurs.

An important precedent has been formed in the combination of study not only of defects of vision but also the conditions of illumination responsible for them. Thus it will be seen that the question of the standard of vision of employees during their period of apprenticeship is to be considered, and also the proper lighting of factories. Another problem for investigation to which we have referred before in these columns is that of the effect of intense radiation in possibly causing cataract. It will also be seen that the programme contains a reference to photometrical processes, which are probably necessarily intimately connected with any adequate study of conditions of illumination, though it has not always been realized in the past. The account of the proceedings of this Congress will be awaited with interest.

Announcements of the Iron and Steel Institute.

We are informed that the annual general meeting of the Iron and Steel Institute will take place at the Institution of Civil Engineers, Great George Street, London, S.W., on May 4th and 5th, 1910, and the annual dinner will be held, under the presidency of His Grace the Duke of Devonshire at the Hotel Cecil on Wednesday, May 4th. The autumn meeting of the Institute is to take place at Buxton on September 27th, 28th, and 29th, 1910.

Attention is also drawn to the International Congress of Mining Metallurgy, Applied Mechanics, and Practical Geology, which is to be held at Düsseldorf in the last week of June, 1910. All particulars can be obtained from the Secretary, Mr. G. C. Lloyd, 28, Victoria Street, S.W.

The Need for the Measurement of Illumination: Daylight and Artificial.

(*Paper read by* Mr. P. J. Waldram, F.S.I., *before The Society of Architects, January 13th*, 1910, *at* 8 p.m.; *abbreviated.*)

The daylight and artificial illumination of buildings is a matter which the architect is constantly called upon to determine, and to determine in most cases for the whole life of the building. It is difficult to imagine any building where the decisions of the designer with regard to the shape and size of windows and the provision of artificial illuminants are not of the utmost importance. In schools, libraries, hospitals, and workshops the efficiency and sufficiency of the lighting has to be his first consideration, and in very few buildings indeed can he afford to make it a secondary one.

At the same time, rooms which are built with an unduly large proportion of window space can only be warmed with difficulty and at great expense, whilst in summer they are insufferably hot. Even greater care has to be exercised in order to avoid excessive artificial lighting, which is not only expensive, but extremely detrimental to the eyesight.

One would therefore naturally expect the subject of illumination to have been fully investigated by architects, and to receive from students as much attention as the proportions of Greek temples. One would expect that it would be the subject of minute regulations in the London Building Acts and in local By-laws, in the regulations of the Board of Education, and in the Government requirements for the proper lighting of factories and workshops. It would be expected that in the intensely populated towns and cities of England, where land is valued by the square foot, and almost by the square inch, and where a light well costs a modest competence in dead rent, that the limiting angles of good, bad, and indifferent lighting would be known exactly. But this is hardly what we do find. What is the information possessed by the average architect upon the subject of windows? He knows that the window space of every room should be at least one tenth of the floor space—text-books written 100 years ago will tell him that—and he probably knows that the same proportion in schools should approximate to one-fifth. But how many could say what proportion of the outside daylight is enjoyed in any room; how many could say what difference would be caused by any given degree of obstruction; or whether the height of the window head makes any difference? How many can define the relative efficiencies of a square foot of glass in a wall and a square foot of glass in a skylight? How many can tell a client what would be the relative amount of light absorbed by or reflected from wall papers of different colours, or by different kinds of glass?

With regard to artificial light many architects know that a provision of 30 candle-power per square 100 ft. super of floor area is considered ordinary, that 50 candle-power per square gives bright, and 60 candle-power per square gives brilliant effects. But how many can say at what height from the floor the lights should be placed in order to give these effects, what would be the results at other heights, or what would be the effect of using frosted or tinted globes or shades, and whether the result would be the same with many lights or few?

There is no technical literature on the subject. The average architectural school gives perhaps one lecture

on window areas to third or fourth year students, whilst the subject of different systems of artificial lighting is ignored as completely as it is in the syllabus and papers of the qualifying examinations. One seldom finds illumination referred to in the architectural technical press, and then only in vague and general terms, and as far as the author is aware no architectural institution has ever suggested the formation of a committee to investigate it and collect information.

The Building Act and local By-laws merely demand a minimum proportion between window and floor area, irrespective of whether such windows are at the bottom of a deep area or overlooking a park. The Regulations of the Board of Education for new schools (1907) are excellent as far as they go, except that they forbid the most efficient possible window, viz., a ceiling light. But they do not go very far. and they are absolutely silent upon the subject of artificial lighting. Details for the approval of the Board are required of sanitary arrangements, ventilation, boundary walls, desks, fireplaces, &c., but artificial lighting is not even mentioned. The requirements of the Home Office with regard to the lighting of workshops is that it should be "adequate," which is, to say the least, a little indefinite.

The reason for this state of surprising ignorance is not far to seek. Exact knowledge is impossible without measurements and standards; and the measurement of light has been unfortunately confined almost entirely to the measurement of the *intensity* of light sources, whilst the measurement of results, *i.e.*, the general illumination to be derived from arrangements of lamps, has been neglected. A few weeks ago, the author asked three well-known electrical firms to tender for the wiring of a village hall on the basis of a given illumination at a certain height above the floor. The reply of each one was to the effect that having no data on illumination they were unable to tender.

In the second place the measurement of such an everyday matter as daylight has not been considered worthy of attention. In consequence, the inaccuracies and vagaries of the human eye remain unknown, and it is commonly regarded as an efficient instrument for measuring illumination. As a matter of fact, the impressions received by the eye are no more an accurate criterion of daylight illumination than a landscape photograph is a measure of the acreage of a field. A piece of printed paper upon a table in the centre of a room upon a fine day appears to be illuminated to very much the same extent as when it is held outside the window. But try to photograph in the two positions; outside it may require say one-fifth of a second or less, inside it will probably take five minutes. The photographic plate records a difference in the relative illuminations of no less than 1,500 to 1; to the human eye this enormous difference is almost imperceptible. This is only one instance of the utter unreliability of the eye as a measuring instrument. Many others might be cited. For instance, most people would feel insulted if it were suggested that they were unable to estimate the relative brightness of different classes of sky such as :—

1. Cloudless.
2. Blue predominating.
3. Clouds predominating.
4. No blue.
5. Overcast.

But nine people out of ten who were not expert photographers would place them in the wrong order. Very few would expect to find that clouds *increase* illumination, still fewer would believe that the illumination from a cloudy sky is more than double that received from a clear blue.

Again, the effects of different tints of wall paper on the eye are most extraordinary. Nearly everyone would be favourably impressed with the lighting of a room papered in light pink, and would be extremely liable to consider inadequate that of a room with light buff or pale grey walls. Yet the latter colours reflect nearly four times as much light as pink. Certain wall papers mean a very considerable difference to one's bills for artificial light.

How many people would hold up the Strand Law Courts as an example of daylight lighting ? But try and read a piece of fine print at sunset in the witness box or counsel's seat of any of the Courts, and afterwards try it at the same hour in the centre of an ordinary office with large windows ; the difference is surprising. The chief reason for this is that the windows are high up in the walls, and the enormously high relative value of high angle light is a matter of which the eye takes little notice, and which is seldom properly recognized.

A very little consideration of these facts will show that unaided visual impressions are quite worthless as a criterion of the daylight illumination of any room, and how extremely unlikely it is that different experts, trusting to their eyes alone, will arrive at the same opinion ; for it is no exaggeration to say that there are few experts who know how to *mistrust* their own eyes to such a degree as will enable them to form approximately reliable opinions.

[Mr. Waldram then proceeds to describe his arrangement for comparing the daylight-illumination in a room with that due to the unrestricted sky outside, and concludes by giving a series of data for different buildings in London. This matter has been previously dealt with in this journal. See *Illuminating Engineer* (London), July, 1909, p. 469, Oct. 1908, p. 811.]

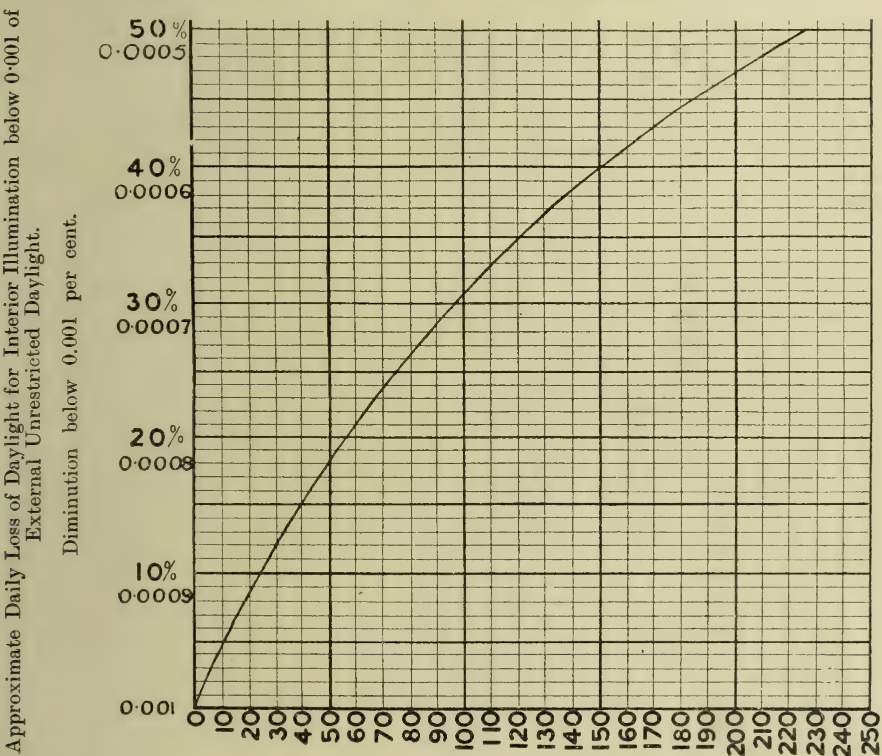

Fig. 1.—Extra Minutes of Artificial Lighting required to maintain a minimum of 1 candle foot.

In cases where the obstruction of the visible horizon has already taken place, the proportion of light still remaining can be compared with that of other rooms in the neighbourhood ; but the more customary problem is to estimate the future damage of a proposed obstruction. This can be ascertained in three ways.

(1) By erecting the proposed obstruc-

tion in the form of temporary screens and noting their effect on the percentage of light enjoyed.

(2) By reproducing the room and its aspect in a scale model and similarly noting the effect.

(3) By reducing the damage from known and recognized data of the difference caused by any given degree of obstruction.

The first two methods are comparatively simple, and they are the only ways open to us at the present time; but if we only had the data referred to in (3) the trouble, anxiety, and needless expense of ancient light disputes might be avoided altogether, and at the same time one of the greatest difficulties connected with town building would become a matter of simple calculation.

Finally, we have to consider what is the real effect of any given obstruction. Over the greater part of the working day it is negligible, for if a room be lit at all at sunrise and sunset, then it has a very large excess between those hours. It may suffer æsthetically, and in rental value, from loss of prospect; but prospect is not an easement.

The real loss, as regards reading, writing, and industrial occupations, is that more artificial light will be required in the morning and evening. The extent of this loss can only be exactly arrived at if the average of increase and decrease of outside daylight be known. There is need for exact and authoritative data, but approximately this may be put at a rise or fall of about 1,000 candle-feet in 45 minutes on clear days in June, and in 180 minutes in average weather in December. In other words, at a point in a room enjoying $\frac{1}{1,000}$th of the outside light the illumination would increase and diminish at the average rate throughout the year of about 1 candle foot per 120 minutes. But a room only enjoying half that proportion would require twice as long to acquire a working light in the morning, and would lose it so much sooner in the evening.

A rough approximation of a standard well-lit room would be one enjoying an average of 1 candle-foot (*i.e.*, a fair reading light), at half an hour after sunrise and at sunset on a clear day, which is given by a proportion of about $\frac{1}{1,000}$th of the outside illumination. Fig. 1 shows approximately the number of minutes of artificial illumination per full *working* day of sunrise to sunset, which would be necessitated in such a room by any given degree of damage. The cost of this can be readily ascertained and capitalized.

The great present-day need is that architects should take an active and intelligent interest in illumination. They can at least insist that gas and electric subcontractors should guarantee a given illumination at table height in candle feet. The demand will soon create the supply, and instruments for testing the results are neither expensive nor difficult to use. But above all, we need workers who will record data and results. Architects, and architects alone, can do this satisfactorily, and their labours would benefit not only their own profession, but the whole of the working community.

An interesting discussion followed in which Mr. A. P. Trotter, Mr. L. Gaster (London), Mr. G. A. Birkenhead (Cardiff), Mr. C. E. Jackson, Mr. R. G. Bare, Mr. T. Lidiard James (London), Mr. J. Todd, and Mr. A. Alban Scott (London) took part, and Mr. P. J. Waldram subsequently replied to the various points raised.

Mr. J. W. Dyson was in the chair.

The Appeal to the Eye in Electioneering.

The recent election may be said to have provided food for reflection for the illuminating engineer on account of the extraordinary development in the efforts made by both sides to appeal to the eye. Probably on no other occasion has such a liberal use been made of posters and of lanterns and transparencies for the announcement of election results all over London. When both parties are striving to catch the eye of the elector the question of how a picture is illuminated, as well as what it contains, is surely one not lightly to be dismissed.

The Physiological Effects of Radiation.

By Dr. C. P. Steinmetz.

(Address before The Illuminating Engineering Society in the United States, Third Annual Convention, 1909. Abbreviated.

During the last years considerable discussion has taken place on the harmful effects of radiation, more particularly of ultra-violet light, to such an extent that in illuminating engineering ultra-violet begins to assume the same position which resonance once had in electrical engineering, to be the scapegoat which is blamed for everything we do not understand.

However, it cannot be denied that artificial illumination is more harmful, more severe on the eyes, than daylight. In the last years a rapid advance has taken place in illuminating engineering. New illuminants of higher power, of a whiter colour—that is, a colour more nearly like daylight, hence of shorter wave-length, than the illuminants of old—have been introduced. During the same years the frequency of affections of the eye, due to working under artificial illumination, has seriously increased. We also know that ultra-violet light is harmful. You see, then, it is very easy to draw the conclusion, and the conclusion has been drawn, that the increasing frequency of eye troubles is the result of the development of illuminants of shorter wave-length or higher frequency of light, and due to the higher percentage of ultra-violet and harmful radiation, contained in these modern illuminants, as the tungsten lamp and the arc, compared with the gas flame and kerosene lamp of old. Nevertheless the suggestion that the ultra-violet radiation contained in these modern illuminants may be guilty of the harm is refuted by the fact that daylight contains a higher percentage of ultra-violet light than any modern artificial illuminant in general use.

For we must remember that in former days, when the tallow candle was the best illuminant, affections of the eye, due to working under artificial illumination, obviously were unknown, because there was no illumination of such a character that work could be carried on under it. With the advance of the art, and the development of better illuminants, it became more and more possible to do close work under artificial illumination, and as a result more and more eye affections became possible by working under artificial light. Ultimately, in the last few years, we have succeeded in producing illuminants with an intensity and a quality of colour almost equal to daylight, under which conditions it has become possible to do practically any work under artificial illumination; and it has become possible, instead of being limited to six or eight hours close work during the day, to extend the time of close work to ten or twelve hours. The result is necessary and obvious—that the strain on the eye during the long continued work is greater than can be recuperated from during the period of rest, and as a natural conclusion we must expect that affections of the eye become more frequent, resulting from the possibility of extending the hours of work, and the possibility of working longer under artificial illumination. But this is not a fault of the artificial light.

However, there are undoubtedly certain harmful effects inherent in artificial light. There are harmful effects, also, in daylight, when used improperly; but the latter is not the topic of our discussion—we are discussing only artificial light here.

Artificial light can be made very harmful by improper illuminating engineering, or the absence of all illuminating engineering, as has been discussed

before : too high or too low intensity ; location of the light sources in the field of vision, and in general excessive intrinsic brilliancy—and unfortunately some of the most modern illuminants are almost criminally offensive in this respect—improper proportion between directed and diffused light ; improper direction of directed light ; improper density, location, and termination of shadows, &c., are all causes of unsatisfactory, that is, harmful illumination.

If we desire to assort or separate different shades of white and yellow and brown and red, under the incandescent lamp, it imposes a much greater strain on the eye than to do this by daylight, because the differences are much less distinct, and that means, necessarily, that it is harmful to the eye by overstrain. For other purposes, again, where we desire to distinguish, for instance, blue and white, the incandescent lamp may have an advantage over daylight, because these distinctions become greater. So we find that for some purposes, some distinctions of colour, the incandescent light may be actually superior to white daylight. For many purposes, however, it is inferior, and therein lies the disadvantage and resultant harm of coloured light for the distinction of objects. In certain cases, again, as in machine-shop work, where brass and copper is handled, the mercury lamp would have a disadvantage, because the difference in appearance between brass and copper is reduced in the greenish light of the mercury lamp, this distinction made less sharp, and therefore it is harder on the eyes to distinguish the two substances from each other. It is the field of the illuminating engineer to choose as far as possible that colour tinge of the light which is best suited for the particular purpose for which the light is used, to bring out those distinctions most sharply, and not obliterate them.

In general, however, this effect is pointing to that direction to which modern illuminating engineering trends, that the white light is the most desirable, the nearest approach to daylight, and, as you know, we are getting nearer to it—the incandescent lamp is whiter than the gas flame or kerosene flame, the tungsten lamp whiter than the incandescent carbon lamp, but even the tungsten lamp is still decidedly yellow.

A second harmful effect of radiation is the direct power effect. Radiation is power, and, as such, when entering the eye, is absorbed, that is, converted into heat, and when of an excessive intensity becomes harmful. In the eye we have a protective mechanism guarding against the entrance of excess light. For sudden excess light the eyelids close automatically. Moderate excess light causes the pupil to contract, and therefore to reduce the amount of light which enters the eye. However this protective mechanism does not afford complete protection. The contraction of the pupil reduces the entrance of light to an amount which is not rapidly harmful, but still admits a sufficient amount of light to become harmful when the eye is exposed to it for a long time—for instance, when tending a furnace as fireman, or in a similar capacity. We find that sufficient power of radiation enters the eye to cause after some time harmful effects, inflammation.

The affection resulting therefrom, "power burn," gives a certain definite set of symptoms. Where it is acute, as in the case of exposure to an explosion or a short circuit, the effect appears instantaneously, or immediately after exposure, in the form of temporary blindness, followed by effects of the nature of an inflammatory affection. In this case of power burn, the external effects are very pronounced and marked ; they appear formidable—redness, swelling, tears, acute pains, but their characteristic is that recovery is also very rapid and practically complete—even in the case of quite a severe power burn recovery usually results in a few days, so that the effect is more serious-looking than actually harmful, although, naturally, it is not advisable to look at a short circuit if you can help it.

In causing a power burn, most artificial illumination is decidedly more harmful than daylight. Most artificial illuminants derive their light from

temperature-radiation, that is, the light is given by high temperature of the radiator, by incandescence, from filaments, or the incandescent carbon particles in the flame, or the incandescent carbon tip of the arc lamp. Of the total radiation in these cases, an extremely small fraction is visible; most of it is invisible ultra-red radiation power. The amount of power, therefore, which enters the eye from an incandescent lamp, or a similar source of light, is very many times greater than the amount of power which enters the eye together with, or as the result of, the same intensity of illumination from daylight.

These illuminants, which are not based on temperature radiation, but on selective radiation or luminescence, usually have a much larger percentage of visible radiation, amongst the total radiation, and therefore are less harmful. Thus the light of the Welsbach mantle is much less harmful than the light from a kerosene lamp, because, with the same amount of light, the total radiation power is very much less.

In addition to the effect of radiation power in the eye, the power burn, there is a specific effect of certain wavelengths of radiation, mainly the ultra-violet light. This effect is still absent in the green light, possibly begins to a very slight extent in the blue and violet, and increases in the ultra-violet, reaching a maximum at the extreme end of the ultra-violet, and persists, possibly reduced in intensity, up to the X-rays. This specific action is a harmful action—it causes what may be called an *ultra-violet burn*. We must realize that the range of ultra-violet radiation extends over more than twice the range of the visible light; that is, the range from the longest ultra-violet waves to the shortest ultra-violet waves is about two octaves, while the entire range of visible light, from the red to the violet, is less than one octave.

We may most conveniently consider three sections of the ultra-violet spectrum, the *long ultra-violet waves*, that is, ultra-violet light from the visible violet radiations, to a quarter or possibly a half octave into the ultra-violet, that is the lowest frequencies or longest waves of ultra-violet light. Beyond this we get what we may call the moderate or medium frequency, or *medium wave lengths of ultra-violet light*, half an octave or so beyond the visible, and then the *high frequency ultra-violet waves*, the shortest ultra-violet waves, from one to two octaves beyond the visible.

These three parts have very different effects. The low frequency ultra-violet light is practically harmless. If of very excessive intensity, it may cause, and does cause, ultra-violet burns, but if of moderate intensity, the form in which it exists in daylight, it is harmless, and in that still more moderate intensity in which it exists in artificial illuminants it is still more harmless. Harmful effects, however, exist in the medium wave-lengths, in the ultra-violet light about one-half octave or three-quarters of an octave beyond the visible. This medium high frequency ultra-violet light is very decidedly harmful to the eye. It causes, even at moderate intensity, a very severe affection of the eye. When you come to the high frequency ultra-violet waves, they are destructive to the eyesight. Exposure to a moderate intensity for a few minutes only, results in very severe affections from which recovery is very slow, and in some cases has not yet occurred completely after eight years since the harm was done. So you see the danger of ultra-violet light increases very greatly when we come to these higher frequencies or shorter wave lengths.

The "ultra-violet burn," in its symptoms, is distinctly different from the "power burn." The external appearance of the inflammation is, in this case, very insignificant, frequently absent, but the effect is extremely permanent — lasting, even in mild cases, for weeks, and in more severe cases for years, while complete recovery may never occur.

In chronic cases, in continued or frequent exposure to ultra-violet light of moderate intensity, as, for instance, when working near open arcs, that is, arcs not protected by glass globes, near spark discharges, as at the

sender of the wireless telegraph station, an ultra-violet burn appears as a chronic affection, and the two characteristic symptoms are headache, occurring with increasing frequency, and what may be called a blurring of the vision. That is, the first effect generally is that of headache, occurring with increasing frequency, which may be characterized either as headache or as eyeache, a deep-seated pain at the back of the eye. It is very frequently for a long time not assigned to its real cause, because there is usually some temporary reason, some slight indigestion or so, which brings it about, until the increasing frequency of the occurrence and the severity of the symptoms leads ultimately to a suspicion of the real cause, the exposure to the ultra-violet light. The second effect is a blurring of the vision, that is, in such cases you may see clearly, the eyes are perfectly able to focus, but you cannot keep anything in focus for any length of time.

In the case of flame arcs and luminous arcs, it is not safe, even for a short time, to be exposed to the light of the flame arc or luminous arc, when it is not enclosed by a glass globe, and any experimenter who has anything to do with them must be cautioned to be sure that he has a glass globe around the arc, otherwise when he works with the exposed arc for a few hours he may have some weeks' time to think over how foolish he was. The ultra-violet light of the flame arc and luminous arc extends only to medium high frequencies, and the very high frequencies have so far only been observed in the light of the low temperature mercury arc. Since glass is entirely opaque to these high frequencies, a mercury arc enclosed in a glass tube is harmless, because while the high frequency waves are produced inside, they cannot pentrate through the glass. In the quartz tube you get these extremely high frequency radiations.

Ultra-violet radiation of medium frequency, that is, of considerable harmfulness, is also produced by spark discharges, and by vacuum discharges in the Geisler tube, and it is quite possible the Geisler tube discharges may give even these extremely high frequency, extremely destructive radiations, the same as the low temperature mercury arc. Since the vacuum discharge is always operated in a glass envelope, you do not get this high frequency of ultra-violet light outside, but if anybody desires to experiment with a vacuum discharge in quartz tubes he should be extremely careful.

Incidentally, the characteristic of these most destructive high frequencies of radiation is that they produce ozone from the air, and they can, therefore, be recognized by the odour of ozone. A low temperature mercury arc in a quartz tube causes a very intense smell of ozone which it produces. Possibly the extreme destructiveness may be the same effect which produces ozone, that is, it causes resonance vibration of the oxygen atoms, and thereby dissociates and destroys living tissue. In the middle range of the ultra-violet radiation, we have as a characteristic distinction that the mineral willemite, the native zinc silicate, fluoresces bright green; it does not fluoresce in the blue or violet, and it does not fluoresce in the long ultra-violet light waves, that is, waves which are nearer to the visible light, and relatively harmless. Wherever you see the green fluorescence of willemite, you know you have ultra-violet radiation of sufficiently high frequency and sufficiently short wave-length to be dangerous.

(*To be continued.*)

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

Glare, its Causes and Effects.

Discussion of the Society at the House of the Royal Society of Arts (London) on January 11th, 1910.

A MEETING of the Illuminating Engineering Society was held at the House of the Royal Society of Arts, London, on Tuesday, January 11th, a number of distinguished visitors being present. The chair was taken by the President, Prof. S. P. Thompson, F.R.S.

The President called upon the Hon. Secretary to read the minutes of the last meeting, and the names of a number of new members of the Society (which are published on p. 131 in this number) were then announced.

The President then explained that, owing to the wide scope of the questions to be studied in connexion with this subject, it had been thought desirable on the present occasion to restrict the discussion mainly to the physiological and hygienic aspects of the matter, and to deal with the more familiar applications at the next meeting.

Dr. J. Herbert Parsons, F.R.C.S., was then called upon to open the discussion. At the conclusion of Dr. Parsons's remarks (which will be found *in extenso* on p. 99), the President called on Mr. J. S. Dow to read an abstract of some of the chief points in connexion with the very exhaustive series of communications from members residing in the United States and on the Continent.

The President also explained that, in order to give some idea of the scope of the discussion, a series of questions on points on which fuller information was desirable had been circulated among members of the Society and other authorities likely to be interested, and a very striking response had followed. It was of course impossible to do justice to these valuable communications in the short time at his disposal, but the contributions would be published *in extenso* in the next number of *The Illuminating Engineer*. Mr. Dow then proceeded to read out extracts from a number of the replies received, mentioning in each case the name of the authority responsible and his locality.

An interesting discussion then took place in which **Dr. Edridge Green**, **Dr. F. Gans**, **Dr. W. Ettles, Dr. James Kerr** (Medical Officer to the L.C.C.), and **Dr. T. M. Legge** (H.M. Inspector of Factories) took part.

In closing the discussion about 9.45 P.M. **the President** said that he felt sure all present would thank Dr. Parsons, and the other gentlemen who had participated for having put the matter before them in such a lucid manner. It was evident that there was a good deal of work still to be done in order to arrive at unanimity of opinion.

Mr. L. Gaster, Hon. Secretary, said that he would like to make special reference to the valuable character of the contributions received from their friends on the Continent and in the United States. He felt that it was mainly by co-operation of this kind that such matters could be decided, and he thought it might be desirable, as one of the corresponding members of the Society, Dr. Stockhausen, had suggested, to nominate an international committee subsequently to deal more fully with the question of glare.

The President then announced that the discussion would be adjourned until Feb. 15th, and most of those present proceeded to the library, where tea and coffee were provided.

The Illuminating Engineering Society.

(Founded in London, 1909.)

Glare, its Causes and Effects.

THE following list of queries, dealing with the above subject, was circulated previous to the last meeting of the Society on January 11th, and was also published in the January number of *The Illuminating Engineer* (p. 11). The interesting and exhaustive communications from foreign members of the Society, published in this number, were received in response to this appeal.

This discussion will be resumed at the next meeting of the Society to be held at the House of the Royal Society of Arts (John Street, Adelphi, London), at 8 P.M., on **Feb. 15th 1910,** and it is hoped that those who desire to participate, but are unable to be present, will send in contributions in writing to the Hon. Secretary as early as possible. Communications intended for publication in the March number of *The Illuminating Engineer*, must reach the HON. SECRETARY, MR. L. GASTER, 32, VICTORIA STREET, LONDON, S.W., before **Feb. 20th, 1910.**

List of Queries:—

1. What exactly constitutes a "glaring" system of illumination ?

2. Evidence is needed of instances in which undue brilliancy of injudiciously placed sources of light has been unquestionably prejudicial to eyesight. Suggestions for the collection of data regarding eyesight and health and conditions of illumination enjoyed by school children, &c.

3. Is it desirable to recommend that sources of a brilliancy higher than a certain limiting value should never be used unscreened in interiors ? Or that such sources should always be placed a certain minimum distance from the ground ?

4. What is the maximum intrinsic brilliancy on the part of an illuminant which can be considered physiologically harmless, under ordinary conditions ? To what extent is the glaring effect of bright lights dependent on the distance of the eye, on "brightness per unit area," and on the area and total amount of light radiated by a source ? In what manner is the desirable intrinsic brilliancy of an illuminant governed by the brightness of surroundings and by the area over which the glare is distributed ?

To what degree is the sharpness of the shadows cast by concentrated sources of great brilliancy responsible for glare ? Is the effect of glare rendered more acute by variations in the intensity of an unsteady source of light ?

5. Is there any reliable and simple physiological test by which it can be readily ascertained whether an existing system of illumination is open to objection on account of glare ? Could the opening and closing of the pupil-aperture be so used ?

6. What instruments are available for measuring in a simple manner the intrinsic brilliancy of any luminous object ? And what accuracy may be expected in such measurements ?

7. Is excess of light of all colours equally harmful ? To what extent are the prejudicial effects of incautious exposure to brilliant sources of light due to ultra-violet rays ?

8. Is the intrinsic brilliancy of some sources used in the streets too high ? And would a restriction of the existing brightness prove beneficial from the point of view of traffic, &c. ? Suggestions regarding the avoidance of glare from the headlights of vehicles, &c.

9. What is the best intrinsic brilliancy for illuminated signs and advertisements ? And how is this affected by the distance away from which they are to be viewed ?

10. Should any recommendations as to the limiting brightness of illuminants, and illuminated surfaces, such as shades &c., in interiors, be made from the artistic standpoint ?

11. Actual examples of practical cases (*e.g.*, well-known buildings, shop-lightings &c.) in which insufficient attention has been paid to securing absence of glare or specially successful means adopted to avoid it.

Illuminating Engineering Society
(Founded in London, 1909)

Glare, its Causes and Effects.

By J. Herbert Parsons, D.Sc., F.R.C.S.

Opening the discussion at a meeting held at the House of the Royal Society of Arts (London) on January 11th, 1910.

SYNOPSIS.

Examples under natural conditions.
,, ,, artificial ,,
,, ,, pathological ,,
The Physiological Problem:—
Retinal adaptation.
Spatial induction.
Insufficiency of the protective mechanism.
The Physical Problem:—
Luminosity.
Colour.
Ultra-violet rays.
The Psychological Problem:—
Pain.
The rôle of the fifth nerve.
"Photophobia."
Effects of Glare.
Conclusion.

It is perhaps scarcely necessary to define what is meant by "glare." Every one is familiar with the uncomfortable sensation experienced when a bright light shines directly into the eyes, and we may accept this example as a sufficient indication of the meaning of the term. It is only when we begin to analyze the conditions, physical and physiological, which give rise to the discomfort that we fully realize the complexity of the task we have undertaken.

Before discussing the conditions which give rise to glare in employing artificial methods of illumination, it will be well to remind ourselves of familiar examples under natural circumstances. Here the physical data at our command have been firmly established by long and patient investigation, with far greater certainty, indeed, than in the use of the relatively less complicated conditions of up-to-date artificial illumination.

We have all experienced the discomfort of glare off the sea in bright sunlight. Perhaps the discomfort has been enhanced for us by the associated pangs of *mal de mer*. Another striking example is the glare from a wet road when the rain has not long ceased and the sun has broken through the clouds somewhere in the line of vision. Glare is common in southern countries, where the sun is bright, the atmosphere clear, and the ground surface white. It is to be noted that under such circumstances glare may be experienced even when the sun is not shining directly in the line of vision; indeed it may be actually behind the observer's back. Further, it should be noted that glare is absent or little marked in tropical countries where the surface of the ground is covered with grass or other vegetation.

I think that these examples may afford us some clue as to the physical conditions underlying glare. Another example will put us on the track of the physiological basis of the phenomenon. If one passes from a dark room suddenly into bright sunlight glare is experienced in a peculiarly acute form. It may be several minutes before objects can be distinguished at all clearly, and yet longer ere they can be viewed with comfort.

Under artificial conditions glare is experienced in an acute form when a bright light is situated almost in the line of vision between the eye and the object observed.

I will permit myself one more example taken from a pathological or abnormal

condition. People are sometimes born with little or no pigment in any part of their bodies. As you know they are called albinoes—their hair is white or extremely pale in tint, their irides are red owing to the blood circulating in the vessels, and their eyes show rapid oscillations, a condition known as nystagmus. These people suffer much from glare, even under circumstances which cause no discomfort to normally constituted individuals. Much of their distress is alleviated by the use of tinted glasses which modify the intensity of the light which reaches their retinæ.

Since glare is essentially an uncomfortable sensation, it is clear that the fundamental point in the problem before us is physiological. The eye shows a marvellous adaptability to extremes of intensity of illumination. Under favourable conditions small print may be read easily by the feeble light of a farthing dip or in the brilliant blaze of a southern sun. Experiment has shown that the sensitiveness of the retina to impressions is enormously increased by protecting the eye from all light. If the eyes are lightly bandaged so that no pressure is exerted, but light is effectually excluded, in the course of about half an hour the retina reaches its maximum sensibility. It is then possible to perceive a glimmer of light which is quite invisible under any other conditions. Exposure to light, on the other hand, causes diminution of retinal sensibility, so that a much greater degree of change of intensity of illumination is necessary to produce a conscious impression than in the former circumstances. This constant variation in the sensitiveness of the retina, which obviously subserves so useful a purpose in everyday life, is called retinal adaptation. We have seen that in dark adaptation, when the retina is extremely sensitive, bright light causes an uncomfortable or even painful sensation—in other words, glare. We must conclude, therefore, that the condition of adaptation of the retina is one of the most important factors, if not *the most* important in the production of glare. It is not, however, the only cause, for glare may be induced by less rapid and less extreme variations in illumination than those adduced as examples.

It will have been noticed that in most of the examples of the occurrence of glare in natural circumstances it is caused by strong light reflected upwards into the eyes from the surface of the sea or ground. It would appear, therefore, that light entering the eye in such a direction is particularly prone to initiate the symptoms. In most circumstances only relatively feeble diffuse light enters the eye, for the sun or other source of light is high above the observer and the eye is protected from the direct rays by the overhanging brow and lids, to which is often added some form of artificial head-gear. Light strongly reflected from below is for the most part worse than useless for visual purposes, as you must have often observed in reading books printed on highly glazed paper. It is detrimental to clear vision for two reasons. To take the example of the printed page. First, it obscures the contrast between the letters and the paper. No ink is so black that no light is reflected from it. By strongly increasing the intensity of the incident light the increase in the reflection of light from the ink is greater in proportion than the increase in the reflection from the paper, and hence the contrast which is so essential to clear vision is diminished. Secondly, many of the reflected rays impinge upon the retina in the immediate neighbourhood of the retinal image, so that the contrast is further diminished here. Sharp definition depends largely upon the contrast between the retinal image and the surrounding area of the retina. By a physiological process which was first pointed out by Hering, and is known as spatial induction, the sensitiveness of the surrounding retina is relatively depressed, particularly at the junction of the reacting surfaces. Flooding the retina with diffuse light must necessarily depress this reciprocal action and diminish the sharpness of definition of the image.

It might be argued that glare is often caused by *excess* of contrast, as in the

familiar examples of the intensely bright beams of light from a lighthouse or the acetylene lamp of a motor at night. Analysis of the conditions will, however, show, I think, that the same causes are at work here, augmented by an unusual degree of dark adaptation of the retina.

Owing to the inherent defects of the optical apparatus of the eye no retinal image is absolutely sharp : there is, therefore, a natural tendency to diffuseness of the image, no matter how perfect the eye, and spatial induction is apparently devised specially to counteract this irradiation, as it is called. Anything, therefore, which interferes with spatial induction must interfere seriously with clear vision.

The eye possesses an automatic protective mechanism against the influence of bright light in the iris. This acts as a diaphragm, which contracts concentrically, thus diminishing the size of the pupillary aperture, when the incident light is increased. By diminishing the aperture it also reduces spherical aberration and tends to eliminate irradiation. The range of the apparatus is not sufficiently great to abolish the evil results of intensely high illumination, as is shown by the cases of serious permanent defects of vision which follow looking at eclipses of the sun and exposure to the bright flash of a short circuit with unprotected eyes. Hence the very *intensity* of the incident light may cause glare and even worse consequences by producing grosser changes in the retina than those which we have been considering. How these act is not yet satisfactorily explained, largely owing to the rarity of the opportunity for making anatomical examination of the eyes from suitable cases. We may conjecture that profound chemical changes occur in the visual purple and even in the structural elements, leading to their destruction and loss of function. It would take me too long and lead me too far to discuss the matter fully, but if the conjecture has any basis we are naturally led on to inquire whether it is the mere *intensity* of the light which is the *causa causans* or whether it is some particular form of energy in the incident rays which brings about the disastrous result.

The incident light is always composite in character. By passing it through a prism it can be broken up into its constituent rays, revealing the coloured spectrum in all its glory. If the prism is made of quartz it may be easily demonstrated by suitable means that there are yet other rays of importance in the ultra-violet region. Since the ultra-violet rays are known to be specially potent in effecting chemical change, attention would naturally be directed first to them. The eye, however, has a very efficient protective mechanism against them, at any rate so far as the retina is concerned, for they are absorbed for the most part by the crystalline lens. As you are aware, much attention is being directed to these rays at the present time, and since it is not probable that they are more than a subsidiary element at most in the causation of glare, it may be well to neglect them in this connexion. Otherwise the discussion may easily transcend the limits which it would be well to put upon it from utilitarian motives.

More to the point is the question whether colour or luminosity is prepotent in causing glare. Instances culled from nature and artifice alike point to the fact that colour is if anything beneficial in reducing the tendency to glare. The natural adaptation of the retina to red has, however, to be taken into account. In mathematical phraseology, I am inclined to think, that so far as the physical side is concerned, glare is a function of luminosity rather than of colour. On the physiological side I opine that temporal induction (retinal adaptation) and spatial induction are the pre-potent factors, the latter specifically invalidated by the direction of incidence of a superfluity of extraneous rays.

In the milder form of glare the discomfort experienced scarcely amounts to pain. It is difficult or impossible to define where one ends and the other commences. Prolonged discomfort—not in itself painful—will undoubtedly induce pain. Here the psychological

factor becomes important. The bombarding of the peripheral mechanism with sub-maximal stimuli appears to produce an accumulative effect upon the central mechanism or brain, leading to the consciousness of pain, which is so assertive that it drowns the specific characteristics of the sensations which have originated it. In discussing a condition like glare, which leaves no permanent traces in the form of anatomical changes in the parts affected, the psychological factor cannot be neglected with impunity. Apart from the pain induced by mere summation of sub-maximal stimuli, it is also caused in the majority of cases by the prolonged efforts to minimize the discomfort. The discomfort of even moderate glare causes screwing up of the eyes and puckering of the brows, and this prolonged muscular contraction is in itself painful. The puckering of the brow is specially liable to cause pain by squeezing the supra - orbital nerve against the frontal bone. Painful impressions induced by the stimulation of one branch of a nerve are liable to spread and be referred to other branches of the same nerve. Hence it is that pain is referred in these cases to many other areas supplied by the fifth cranial nerve, notably in the production of frontal headache.

In the more acute forms of glare, however, pain is experienced at the outset. Now, we have no evidence to show that any stimulus, however powerful, can produce pain through the purely visual nerve tracts. Pain is regarded as invariably due to the stimulation of certain afferent nerves, the nerves of common sensation. The question arises, therefore, whether the pain of glare is not due to stimulation of other nerves than the retina and visual paths. There is an allied condition commonly called "photophobia." When a particle of steel or coal dust gets into the eye, there is an intense spasm of the lids accompanied by a copious flow of tears. The same phenomenon occurs in an inflammatory disease of the conjunctiva, common in children, known as phlyctenular conjunctivitis. Under such circumstances it is difficult to open the eyes at all, and it generally appears to be more difficult in bright light than in the dark—hence the term photophobia, or dread of light. As a matter of fact, it is very doubtful if light plays any potent part in the production of the condition, which is therefore better termed reflex blepharospasm (spasm of the lids). Now reflex blepharospasm is undoubtedly due to excitation of the nerve endings of the fifth nerve in the cornea and conjunctiva, and although the excitation is largely, if not wholly, mechanical in most cases, it cannot be absolutely asserted that light is incapable of stimulating these nerve endings. Other branches of the fifth nerve supply the iris and ciliary body, as well as the choroid, which lies immediately behind the retina. Is it possible that the pain of intense glare is due to over-stimulation of these nerve endings? Although inherently improbable, it cannot be denied that the pain wholly or in part may be due to the irritation of the sensory nerves in the cornea or choroid, in the latter case specially in the macular region, where the retina is thinnest, and in the iris, here brought about perhaps by the intense constriction of the sphincter muscle of the pupil. Further investigation of this interesting problem is needed before any final conclusion can be arrived at.

In the meantime we may leave these rather esoteric conjectures and confine our attention to the more probable explanation already adduced, which at any rate accounts for the visual manifestations of glare and emphasises most clearly the conditions to be avoided.

There are many other points which I might here mention in support of my thesis, notably the penetration of light through the sclerotic, especially in albinoes, the entoptic reflection of light, and so on.

With regard to the *effects* of glare, they may be roughly divided into two groups, the relatively innocuous and the severe. Mere dazzling, attributable to moderately intense illumination, and particularly to widespread diffusion of light over the retina, produces discomfort, which, when prolonged

eventuates in actual pain. The causes of the pain thus experienced have already been considered, and are chiefly due to excessive action of an inadequate protective mechanism.

Severe results are due for the most part to the intensity of the stimulus, which may be extremely rapid in its action, as for example in the case of short-circuiting of a powerful electric current. Various grades may be met with in the visual defect resulting from exposure to bright light. A blurred spot or negative after-image may be regarded as physiological when it is relatively transient, but with greater intensity the blurred spot persists, and may even be permanent: it is then called a scotoma. With the greatest degrees of intensity the scotoma is associated at a later date with anatomical changes in the retina, pigmentation in the macular region, and so on, a condition seen typically in cases of visual defect after observing eclipses of the sun with unprotected eyes. Prolonged exposure to bright light in the tropics and at sea is not infrequently followed by night blindness. These cases are of particular interest, since they show in a marked degree the effects of retinal exhaustion. It was shown long ago that in them if one eye is bandaged and thus protected from light during the day the night blindness is warded off. It is almost certain that the retinal exhaustion in these cases is due primarily to bleaching of the visual purple, which is not restored with the usual rapidity. In some cases of this kind malnutrition plays a part, but others occur without this factor. Night blindness has been known to follow a long motor drive facing the sun, which was near the horizon and consequently shining directly into the driver's eyes.

Now these changes in the retinal purple are chemical in character, and might be expected to be most readily induced by the most actinic rays of the spectrum, viz., the ultraviolet rays. These are known to be responsible for so-called "snow-blindness," but this is a superficial inflammation of the mucous membrane covering the eye and is of a completely different character.

Time will not permit me to enlarge upon the topic further, but I cannot close without expressing the hope that the consideration of this highly complex subject may result not only in a good debate—that is a foregone conclusion in the presence of so many distinguished authorities on light and its uses—but, what is far more important, in the stimulation to experimental research.

Discussion.

Dr. Edridge-Green said that the subject bristled with difficulties and openings for future work. Glare to one person was not so to another. In each particular case the eye was more sensitive to certain lights than to others. In his own case, the mercury light was intensely disagreeable and yet there were men who worked with it in the greatest comfort. He had examined such men and had found in each case a considerable shortening of the violet end of the spectrum. His own violet end of the spectrum was considerably longer than that of most people. He could see in the violet region a distinct light when the majority of people said it was absolutely dark. He had had a very good opportunity of testing this at the National Physical Laboratory a week or two ago against those who were working at photometry, and who would therefore recognise the faintest trace of light; but none there saw as far up into the ultra-violet region as he did.

It was the same with the red end of the spectrum. In this connection there were two important factors to be taken into consideration, viz., the

intensity and the wave-lengths of the light. In his own case there was a glare with a light that most people found quite comfortable. This was probably, with the mercury light, due to excessive photo-chemical decomposition in his eyes. He regarded the visual purple as the sole visual substance; there might be a number of other substances, but he had not been able to find the slightest evidence of them and he saw no necessity for them. The visual purple was a substance which could be split up into innumerable other substances, so that there was a still closer relation to photography, and they could follow his explanations more minutely if they regarded the sensitive layer of the retina as corresponding to the sensitive plate of the camera. This sensitive layer of the retina was a thin layer of fluid which was defined on both sides by a membrane and the nerve endings were dipped in this. It could then be easily understood that when light fell on the eye it would decompose this fluid photo-chemically, thereby sending an impulse to the brain. The yellow spot of the retina was so called because of the yellow pigment which was found in it. This latter had exactly the same effect as the yellow glass in photography. This had been found out by natives in India who used golden yellow glasses in order to hunt later in the evening, and thus get definition which they otherwise would not.

Another point which should be taken into consideration was the power of light and dark adaptation of the retina. One person became very easily adapted to a bright light; another person had a very slow adaptation, either one way or the other. One was slow to dark adaptation and the other to light. In the case of albinos, the visual purple was present. One very difficult thing to tell with any light by mere ocular inspection, was the amount of candle-power. A light which was thought to be very bright might be found to be comparatively feeble on measuring it, and another light which was quite comfortable might be found to be considerable on being measured. A frog was a good example of an animal that did not suffer from glare. It could stare directly at the sun without apparently the least discomfort or even blinking.

Any light which produced photo-chemical action in excess of that required by the eye, in its particular state of light or dark-adaptation, produced glare. We might be sitting in an admirably lighted room reading with the greatest comfort; but on leaving this room and going to a cellar for a quarter of an hour we should suffer badly from glare on returning to the room until the eyes again became accustomed to the brighter light.

Dr. F. Gans pointed out that snow-blindness is one of the remarkable effects of glare, and referred to the account of Lieut. Sir Ernest Shackleton's Anctarctic expedition, in which the explorer very accurately describes snow-blindness. If asked what snow-blindness was he should reply that it was the effect of the "glare" of the snow or, in other words, the reflection of the sunlight from the snow. The same thing occurred in the Alps on the glaciers, or big snow-fields, or desert, when the term snow-blindness would be a misnomer. This "snow-blindness" was an irritation of the mucous membrane of the eye, or it might be an inflammation of the iris; in the more severe cases there were symptoms of æsthenopia and retinal and optic nerve disease. A similar effect was produced by looking into an electric furnace.

The question of what was the cause of snow-blindness was still unsettled, although the majority of physiologists were inclined to believe that it was caused by the ultra-violet rays. Lieut. Sir Ernest Shackleton stated that snow-blindness could be prevented by wearing goggles made of a mixture of red and green glass, this giving a yellowish grey shade, cutting off the ultra-violet rays similar to Schanz and Stockhausen's "Euphos" glass. But the use of such glass also had the effect of reducing the amount of light, and therefore it was not an absolute proof that snow-blindness was prevented by the shutting out of the ultra-violet rays.

Dr. Best in Dresden, moreover, had made the experiments of looking through an ultra-violet glass straight at the glaring sun, when not covered with clouds. He did this for ten minutes without any detrimental effects upon his eyes. This seemed to show that the ultra-violet rays played only a very subordinate role as a cause of the evil effects of glare, though some degree of inflammation might be produced by light of this nature.

Dr. J. Kerr, Medical Officer to the Education Department of the London County Council, said his experience had taught him that glare must be separated up into several different factors. He noticed that individuals suffered from snow-blindness in very different ways. People did not seem to notice the glare on the snow as much as they did on the ice. Probably snow-blindness was mixed up with two things; partly glare and partly superficial irritation which caused conjunctivitis, and considerable secretion about the margins of the lids of the eyes. He thought that snow-blindness might be left out for the present.

When they looked into what glare was, they found two things. There was the glare in connexion with artificial illumination, be it incandescent gas or electricity. This was due purely to the intensity of the illuminating surface, which might be quite small in area.

Then there was the glare which occurred from windows, for instance from windows fitted with fluted glass in schools; also from prismatic glass which was badly set, where there was fairly strong incident light, nearly horizontal coming on to the children. This gave a troublesome glare. In one school house set on a hill with a western window, the glare in the afternoon, when the sun was not shining brightly was very considerable; so much so that the acuity of the children's vision in the afternoon was different to that at any other time of the day, simply from fatigue.

Finally, there was the glare from the surface of the books and from the ink. The latter might be remedied to some extent by using a different coloured ink giving a somewhat matt surface.

When it was remembered that the effect upon different individuals varied so much, they must come to the conclusion that glare was essentially functional under certain conditions. Glare had something to do with adaptation of the eye, and it meant stimulation of the peripheral surface of the retina which did not correspond with the adaptation for the illumination at the macula. The eye was adapted more or less for the central retina, and the periphery was stimulated to a different extent; there was no correspondence between the two, and there was some kind of functional effect. This was theoretically a glare, but different to the glare of a highly illuminated surface. The protective mechanism under ordinary glare, was probably due to the efforts of the eye to accomodate or adapt itself, and the fact that we did not experience glare from the sky under ordinary circumstances might be explained in the same way. The lower half of the retina had been used to, and was accomodated to the fact that the sky was brightly illuminated, whereas the foreground was not; for this reason the effect of glare was at once felt if one lay upon one's back and looked at the bright sky. The upper part of the protective coverings of the eye to a certain extent shaded out the sky, and when taking these things into consideration, there must be two factors quite apart from the other questions of colour. These suggested that for comparatively low intensities with big areas of the periphery of the retina stimulated, there was some functional attempt at adjustment in the eye which caused a strain of some kind or other. For high intensities, and possibly small patches of retinal stimulation not necessarily peripheral, such as a glow lamp, there was an actual physiological change taking place in the retina which if maintained, led to destruction by actual burning out, as in the study of solar eclipses. There were also subsidiary factors such as colour and wave length which came in more in this burning out effect than in the glare

from illuminated windows and from printed books and so on.

Dr. W. Ettles said that in his opinion the side issues had been too prominently dealt with. We should address ourselves to the problem "what happens when a person is said to be blinded—by the glare of a searchlight for instance?"

The predominant part seemed to him to be played by the intraocular dioptric surfaces. Thus in an ordinary biconvex lens we not only had the main beam passing to its focus, but also reflections from the surfaces giving rise to real and virtual images; and we had rays traversing the lens having undergone two internal reflections, and which could be intercepted by a screen so as to obtain a second image of the luminous object.

In the human eye, light was not only refracted by cornea and lens on to the retina for the production of the retinal image, but there were several sets of subsidiary intersections. We had the minute real image of the object as seen in the anterior surface of the cornea, the larger one of the anterior surface of the lens, and a third small bright and inverted image from the posterior surface of the lens. Thus we could see that these three refracting surfaces not only formed the main image but that they used up some of the light as reflectors. There were yet two more internal reflections, and it was these two which are the cause of glare. One of them we were familiar with in physiology when we studied the sixth image of Purkinje by moving a candle held at the temple up and down. The lateral light was reflected by the cornea on to the retina, and we could see entoptically the retinal vessels projected on the wall. This showed that light reflected by the cornea back into the eye was readily visible. In glare, then, we had light reflected from the anterior and posterior surfaces of the crystalline lens on to the anterior surface of the cornea from whence it was again reflected through the lens to the retina. The intersection of the system was near the nodal point of the eye and as its angular aperture was very great, we had a wide cone or brush of light diffusing itself all over the retina. Ordinarily this light was invisible, being only $\frac{1}{40000}$ part of the total incident light, but when the entering light was powerful these internal reflections became very pronounced and drowned our sense of vision to feebly luminous objects. The anterior surface of the cornea was the mirror area. The refractive difference between cornea and aqueous humour was practically nothing, but there was a marked difference of index between cornea and air. This explanation of glare was borne out in the case of old people. The senile lens increased in refractive index so that these internal reflections became much stronger. No doubt that partly explained the small pupils of old age, and why these persons were so given to shading their eyes from a direct source of light.

It seemed to be a general impression that the estimation of effect of submitting eyes to too powerful a light was one demanding complex apparatus. That was not really so. We could estimate the degree of acquired night blindness, for example, by turning down the gas until the lowest line of the test types was just visible to our comparatively unexhausted eye. The visual acuity of the patient would then give us a fraction indicating his loss of vision under like illumination. Another very simple way was to view a luminous source through crossed Nicols and ascertain how much turning was needed to evoke a luminous sense. Yet again, we might use a prism of smoke or black glass, neutralised by a prism, base to apex, of white glass. Such an arrangement passed before the pupil would give us a gradation of luminosity.

Dr. T. M. Legge, H.M. Medical Inspector of Factories, said that Dr. Parsons was well known to him as a member of a Committee of the Royal Society which was now sitting to investigate the subject of glass workers' cataract.

In a recent inquiry that he had made into the subject of glass-workers' cataract what impressed him more than anything else was the fact that it did not matter whether the glass worker was exposed to the white heat of the

melting furnace or the dull red glare of the annealing furnace, the effect on his lens in producing a posterior cortical cataract appeared to be the same when he made a number of control observations among the staff at Woolwich Arsenal, only two persons had anything of a similar nature, one of whom was a man also employed in working at a furnace where there was a dull red glare. He had thought that Dr Parsons would have been able to give some more instances of the effects of glare similar to that, and also as to means of prevention, because it seemed so very difficult to say what was the cause. The heat was great, but it did not seem to be the heat ; was it the light ? if so, from rays of what wave length ?

In conclusion Dr. Legge referred to query No. 9. This contained a reference to the question of the brilliancy of advertising signs, which was one of good taste or bad taste according to the individual. If, as he hoped, the members of the Society were convinced that it was bad, then he hoped there would be no compromise.

The President announced that owing to the lateness of the hour, the discussion would have to be adjourned.

He thought they would all thank Dr. Parsons for having put the matter before them in so lucid a manner. Also they would thank those who had taken part in the discussion. He felt he had learned a good deal. One extremely interesting thing fell from Dr. Parsons, upon the automatic action of the eye. The closing of the pupil was due, Dr. Parsons suggested, not only to the light that actually entered the eye, but also to the light that struck on the corner and on the iris itself. He should like to have an experiment made to demonstrate this. The information they had had about the glass workers' cataract was very suggestive, although it might not be a thing that any or many of them would have to investigate.

After all, he was afraid they had not yet reached the stage of framing a precise definition of glare. He had taken down some half dozen different suggested definitions from different speakers, but none of them agreed. One of the simplest was that put forward by Dr. Ettles, who dismissed it summarily by saying it was excess of light beyond the needs of the situation. He did not agree with that either, because he was quite sure that there were certain glow-lamps in his house which gave him a very unpleasant glare if he looked at them at night, whereas he could look at them, illuminated in exactly the same way, in the daytime, and they did not give him a sensation of glare at all. Obviously this was not excess of light beyond the needs of the situation. We had got to get a little further than even that very attractive definition. He hoped that in the subsequent discussion they would be able to arrive at some consensus of opinion as to what they meant by that simple word "glare." If they got no further than this on the next occasion, than a consensus of opinion as to how they should use the word, and to distinguish between different kinds of glare, and the different things that contributed to cause glare, a good piece of work would have been done.

Dr. W. M. Bayliss, F.R.S., London (*communicated*).—1. A "glaring" system of illumination may, from the physiological standpoint, be regarded as one in which the light emitted per unit area of the illuminant is too great, so that the image formed on the retina produces a painfully intense stimulus.

3. It is desirable that such sources should be so placed that images of them cannot be formed on the retina.

4. Requires detailed investigation by experiment. It appears that glare is more acute when varying in intensity, since the contraction of the pupil is more or less ineffective in such a case.

5. I do not think that the size of the pupil could be so used. It would not sufficiently distinguish between an intense local illumination of the retina and a more general but less brilliant one.

7. There seems to be evidence that ultra-violet light is more injurious, but it is no doubt to some degree a question of whether rays of a particular wavelength are absorbed or not.

8. I think the electric arc has an undesirably high intrinsic brilliancy for street - lighting ; the same total illumination distributed by a larger number of small units would be much better, though probably more expensive.

In general, it appears to me that even metallic filament incandescent lamps have too high an intrinsic brilliancy to be placed in the direct range of vision; they should therefore always be used so that no actual image of the filament is formed on the retina.

Mr. P. J. Waldram, London (*communicated*).—May I draw attention to the significant but seldom recognized difference between the sensibility of the human eye in the presence of (*a*) diffused daylight and (*b*) any form of artificial illumination.

I have been at some pains to take a large number of measurements of sky brightness in London, and the results agree very well with the exhaustive records taken by Dr. Basquin in Chicago, and extending over a period of two years. (*Vide Illuminating Engineer* of New York, December, 1906, and January and February, 1907.) At an hour after sunrise in summer the illumination which falls upon a piece of paper with an unrestricted horizon may be taken to be about 1,000 foot-candles ; whilst at noon it will run up to 8,000 or 9,000 foot-candles.

The average room enjoys a mean illumination of about $\frac{1}{1,000}$th of the unrestricted outside light, but so perfect is the adaptability of the eye to *natural* illumination that we can walk without injury from an illumination of, say, 8 foot-candles indoors to an illumination of 8,000 foot-candles outdoors. That is from one position where a photographic plate requires 3 or 4 minutes' exposure to another position in which it requires $\frac{1}{4}$th second—a difference of 1,000 to 1.

A summer sky with white clouds would possess a luminous intensity of, say, 1,500 candles per square foot, or say 10 candles per square inch. Such an intensity of sky-luminosity is not fatiguing to the eye, nor would it be so in the case of artificial light. For example, a 20 candle-power incandescent mantle presenting 2 square inches of surface would not be unduly dazzling.

But when the respective illuminations are considered, it will be found that whilst the eye will adjust itself to and tolerate enormous differences of diffused daylight, it will speedily resent artificial illuminations outside of a very restricted range.

It may permit a range of, say, ½ to 3 or 3½ foot-candles, but an intensity of illumination above 4 foot-candles is soon felt to be disagreeable. An illumination on printed paper of 100 foot-candles from a lamp is blinding, but the same illumination when received from the sky is a mere nothing. I would suggest that the reason why nearly all schemes of artificial illumination of over 6 foot-candles on the object illuminated produce the optical sensation known as "glare" is the impossibility of securing in rooms anything like the enormous diffusion-area of the earth's atmosphere.

But there is no reason why we should make things worse than they are, and as a practical conclusion I would suggest that all shades and globes which, for purposes of economy, concentrate artificial light rays by reducing their angular divergence are harmful, that their divergence should be *increased* in every possible way, and that economy should be sought for in clean white ceilings, deep white cornices and friezes, and in walls coloured only in those tints which reflect most light and which absorb least.

The Illuminating Engineering Society.

(Founded in London, 1909.)

Glare, its Causes and Effects.

(*Continued.*)

Communications from Corresponding Members.

Dr. Karl Stockhausen (Dresden) :—

(We are only able to publish a portion of Dr. Stockhausen's valuable and exhaustive communication to the discussion on this subject in the present number and reserve the remainder for our next; on this occasion we have selected some of those portions which deal most directly with the physiological aspects of the subjects (Queries 1, 4, and 5) which formed the subject of discussion at the last meeting of the Society on Jan. 11th, 1910.)

For a series of years I have undertaken researches dealing with the subject of "glare," which, however, owing to lack of time and other causes, are still in some respects incomplete, and have not previously been published. More recently Dr. Schanz (who is an oculist in Dresden) and myself have carried these researches further, and devoted special attention to its bearings from the physiologist's and oculist's stand point.

It was, therefore, naturally with great pleasure that I availed myself of the invitation of the Illuminating Engineering Society to take part in this exceedingly interesting discussion. I consider it of the utmost importance that these questions of illumination should be considered not only from the purely technical or "engineering" standpoint (*e.g.* on the basis of efficiency, conditions favouring the best practical distribution of light, &c.), but also from the hygienic and physiological aspect.

As I understand that no restriction has been placed on the information desired from an individual contributor, I hope that the length of certain sections of my reply—notably on Query 3—will be pardoned in consideration of the extremely exhaustive nature of the ground to be covered, and the desirability of a review of a more or less complete character dealing with many of these effects.

Query 1. In answering the question "What, exactly, is understood by a glaring system of illumination ?" we must first form an exact conception of the nature of the physiological processes which give rise to this impression of glare. This sensation arises in the retina of the eye. It manifests itself, subjectively, as a stimulus given to the retina and, objectively, as the action of certain rays entering the eye from outside whose action is dependent on their intensity, composition, &c. In judging this effect therefore, we must remember that we are dealing with a subjective phenomenon, which, like all measurements involving light-intensity, must vary somewhat in the case of different individuals.

This is not the place to enter too fully into details regarding the physiological action of light and the part played by it in causing the secretion and wandering of the pigments in the retina. We are, however, very directly concerned with its action on the visual purple, which, we know, is bleached and photochemically altered by the action of light. This visual purple is "used up" in such a process, and we have what is called a "Dissimilative action."

By this process the visual purple is transformed into a new chemical substance which itself stimulates the light perceiving organs. These organs, in turn, convey the stimulus to the centres of light and colour perception where the analysis of the sensation, as regards colour and intensity, takes place.

Now, since the act of vision is directly dependent on the visual purple, there must be in the eye provision for the rebuilding up of just as much of this substance as is changed by the effect of light. The more powerful, therefore, the stimulus applied (*i.e.*, the more rapid the process of dissimilation to which the eye is subjected), the more powerful also must be the subsequent process of "assimilation" by which

the visual purple is built up again. In the same way the less of the material used up, the smaller the amount which this assimilative action is called upon to produce. The process which thus enables the eye to restore the used-up visual substance, is termed "Adaptation."

The eye can only adapt itself to a certain intensity of light for the power of secretion located in the pigment-layer is strictly limited. *When the intensity of light exceeds a certain margin, a corresponding production of visual material is no longer possible, the rate of using up being continuously more rapid than the rate of restoration.*

This point we term the "*Upper limit of adaptation*" or the upper "Stimulus threshold." There is also a lower limit of the same kind, when the flux of light received by the eye is too small to use up enough material to give rise to the sensation of vision. The range between these two extreme limits is termed "the range of adaptation," in consequence of which a certain definite relation between light-intensity and acuteness of vision exists.

When the upper adaptation-limit is exceeded the normal functions of the eye are disturbed, the formation of active material can no longer keep pace with the stimulus, and the eye is "dazzled" or fatigued. This degree of "dazzle" or glare may be termed "absolute" when the upper limit is exceeded, and is then in a sense permanent, because adaptation is unable to meet the conditions imposed on it. The dazzle which arises from a sudden increase in the light entering the eye, which is nevertheless within the limits indicated above, is, however, only "relative," because the abnormal conditions responsible for the sensation can be and are eventually remedied by the influence of adaptation.

In order to explain completely the processes connected with glare, however, there is yet another important factor to be borne in mind, namely the wandering of the retinal pigment When the retina is illuminated this pigment emerges from the cells at the back of the retina, and forms a light-absorbing covering over the rods and cones which meanwhile retract and shorten. In this way the organs of vision are protected against too rapid dissimilation—until the forward movement of the pigment is complete. In the darkness the pigment wanders back to the outer region of the retina, though this movement is relatively less rapid than its previous advance during the period of illumination.

There is also another subjective symptom relating to the sensation of dazzle to be considered, namely the actual feeling of pain arising from a too intense light. This probably is due to the fact that when the point of maximum consumption of visual material is reached, a number of by-products, such as carbon dioxide, are produced, and, for the time being, collect near the ciliary nerves. Only when, in consequence of the prolonged exposure to a powerful light, an increased flow of secretion has taken place, can these accumulated products be dispersed. The painful feeling may also consist in a manifestation of the process of severe adaptation, and may therefore naturally be expected to vary in the case of different individuals.

All these processes take place almost uniformly over the portion of the retina affected by light when the eye is directed towards an extensive and uniformly strongly illuminated surface (*e.g.*, the sky, brightly illuminated walls of an interior, &c.). When, however, there are introduced into the field of view surfaces of brilliancy far exceeding their surroundings (for example, bright flames, incandescent filaments and mantles, &c.), a specially complete exhaustion of the visual substance takes place in the neighbourhood of the relatively small area covered by the luminous image, and the upper limit of adaptation may be suddenly reached in this locality. In this case we experience the painful sensation characteristic of glare, and the using up of the visual substance is illustrated by the formation of a negative "after-image."

Besides the visible light, the invisible ultra-violet rays between 400 and 375$\mu\mu$, which are able to penetrate

to the retina, may contribute to the sensation of glare. They are also responsible for a secondary effect owing to the fact that they excite fluorescence of the eye-lens, a phenomenon the significance of which, in causing glare, has only recently been pointed out. This fluorescence is also a source of stimulation to the retina, giving rise to a general impression of brightness which appreciably affects the apparent " sharpness " of the retinal image ; in this respect it is analogous to the action of stray light in fogging a photographic plate. But the fluorescence, besides fogging the retinal image, undoubtedly also causes fatigue by rapidly exhausting the visual material in the retina. As an illustration of this effect the author and Dr. Schanz have demonstrated that violent reflex actions of the pupil-aperture and movements of the eye-lids can be produced under these conditions. Moreover, every one has experienced the improvement in the " sharpness " of the visual image when the eyes are screened by the hand from light entering sideways, direct from the source of light. Reflected and " indirect " rays are almost invariably less rich in ultra-violet light than those coming straight from the source. By the withdrawal of these rays, therefore, the fluorescence effect, and the fogging of the retinal image, are considerably reduced.

This somewhat prolonged explanation on the physiological effect of light on the eye has been rendered necessary by the fact that, in my opinion, it is to the physiological aspects we must look for a solution of the whole problem.

A luminous object therefore gives rise to the sensation of " glare " under the following conditions :—

A luminous object is absolutely and permanently glaring (1) when the retinal image of it is so intense that either individual portions of the retina, or the retina as a whole, are brought to a condition in which the " upper adaptation-limit " is exceeded. This condition is characterized by a painful feeling of " dazzle," and the prolonged retention of " after-images " when the source of stimulation has been withdrawn.

(2) When the fluorescence of the eye-lens, arising from the action of the ultra-violet rays, appreciably influences the sharpness of the retina image.

Query 4. We have seen, therefore, that although the sensation of glare must be studied by the aid of essentially subjective methods, there does not seem at present to be any reliable and simple physiological test in existence of which an illuminating engineer could avail himself. The dazzling effect of a source is recognized to be dependent not only on the intensity of the light entering the eye, but, as will be seen later, also to a great extent on its composition. Fortunately there is less difficulty in investigating these data from the physical and objective side. Experience teaches us that the sensation of glare is mainly connected with the portions of the retina of which the brightest image is received, and that it is there that the " after-image " arises. It is therefore reasonable to suppose that a relation exists between the relative degree of dazzle and the concentration of light over the surface of the luminous source. In short we can trace an evident connexion between *glare* and *intrinsic brilliancy* (*i.e.*, light intensity per unit area of radiating surface).

The intrinsic brilliancy of a surface can be readily calculated. It is expressed in candles per square centimetre, or, more correctly, in lumens per square centimetre. The expression of intrinsic brilliancy in terms of candle-power per square millimetre is preferably avoided since it in general gives rise to inconveniently small numbers.

In order to illustrate the increase in the intrinsic brilliancy of recently introduced sources of light I have collected together in the adjacent table figures relating to forty different lamps, from the pine torch and the ancient Roman oil-lamp up to the inverted gaslight, the metallic filament lamp and the sources of the present day. Briefly it will be observed that there has been a continuous rise in intrinsic brilliancy up to the present time. It may well be asked, " Which of these sources possess such an excessive brilliancy as may cause the

upper limit of adaptation of the eye to be exceeded ?"

In the literature appertaining to this subject one often meets the expression of opinion that the value 0·75 H.K. per square cm. represents the highest permissible intrinsic brilliancy from the hygienic standpoint. On the other hand, I have also failed to find any really adequate account of personal experiences and observations to bear out this suggestion. I suppose, however, that this figure is mainly based upon the observation of the sky, a surface which can be observed under ordinary conditions without the sensation of dazzle being experienced. Actual measurements have indeed shown that the intrinsic brilliancy of the sky on average days remains, within fairly narrow limits, near the value 0·75 H.K. per square cm. On other days in June and July, however, chiefly when the sky is covered by bright clouds, the eye might be somewhat dazzled by gazing fixedly at the heavens, and the actual brilliancy is then found to be in the neighbourhood of 0·8 to 1·5 H.K. per square cm.

In general I think it is misleading to draw conclusions about artificial lighting from the observation of daylight conditions, for the circumstances in the two cases differ very greatly, and it is rarely possible to make any really valid comparison. It may be added that daylight is not always ideal, and indeed is often associated with injurious conditions which we rightly do not seek to reproduce in our artificial illuminants. However, until we have established some more reliable and more fully substantiated limit, I see no reason to object to this value of 0·75 H.K. /square cm. Indeed I may add that, as far as my researches have at present been carried, the absolute limit of dazzle would seem to lie somewhere in this neighbourhood.

However, the intrinsic brilliancy of an illuminant is not the only factor to be borne in mind. There are other matters which undoubtedly have an influence within certain limits. One of the most important of these is the size of the luminous surface.

Given two luminous surfaces of equal intrinsic brilliancy, but of different area (and assuming that the upper limit of adaptation of the eye is exceeded in both cases) the larger of the two will be found to be the most glaring. This seems to find an explanation in the fact that while the intrinsic brilliancy of the image formed on the retina is the same in each case, that of the luminous object with the larger area covers the largest portion of the retina, and therefore gives rise to a greater total exhaustion of the visual substance.* On the other hand, if the total amount of light yielded by two sources is the same, but their areas, and hence also their intrinsic brilliancies different, even here, (again supposing that the point of maximum adaptation is exceeded in each case) the source having the larger superficial area may, up to a certain limit, prove the more glaring of the two because the total consumption of visual material is greater. But nevertheless the after-image of the body with the smaller area may be found to be the more persistent.

This may partially explain why the glaring effect of the metallic filament lamp is not so great as might be anticipated from its intrinsic brilliancy. For, considering intrinsic brilliancy alone (and in the case of the Wolfram lamp this reaches the figure 265 H.K. /square cm.), it would appear absolutely impossible to use such lamps without frosted bulbs or other protective device.†

There is also a second reason why the dazzling effect of intensely bright surfaces of small area (such as glow-lamp or Nernst lamp filaments)

* For example compare the figures given for the Auer- and Olso-burners in the table. The intrinsic brilliancy is roughly the same in each case, yet the sensation of dazzle was considerably more severe in the latter case. Again the intrinsic brilliancy of the glass furnace (7·52) is no greater than that of the most powerful incandescent burner. Yet one cannot, without using smoked glasses, look into the glass furnace.

† Thus the incandescent mantle (Mannesmann inverted 32H.K.) and the carbon filament glow-lamp (31·9 hor. H.K.) shown in the table are both about equal as regards glaring effect in spite of the intrinsic brilliancy being 11 times as great in the latter case.

INTRINSIC BRILLIANCY OF VARIOUS SOURCES OF LIGHT.

Source of Light.		Candle-power (Hefner) horizontal.	Thickness of Filament mm.	Length of Filament cm.	Superficial Area cm².	Intrinsic Brilliancy H.K./cm².	Remarks.
Pine Splinter ...		5·66	—	—	25·4	0·223	
Roman Oil Lamp ...		0·85	—	—	1·372	0·618	
Candles	Tallow	1·13	—	—	1·538	0 735	
	Stearine	1·485	—	—	2·24	0·663	
Rape Oil Lamps	Open Lamp ...	0·824	—	—	1·421	0·579	
	"Studier" ,, ...	1·22	—	—	1·37	0·891	
	,, ,, ...	3·15	—	—	2·485	1·267	
	Moderator ,, ...	11·40	—	—	7·54	1·515	
Petroleum Lamps	May's Ideal Lamp	21·2	—	—	1·60	0·983	
	Flat Wick Burner	6·28	—	—	8·38	0·749	
	Round ,,	17·20	—	—	4·67	3·69	
	Incandescent Light	22·3	—	—	18·8	1·185	
Alcohol Incandescent Light ...		28·5	—	—	11·55	2·47	
Gas Lamps	Flat Wick Burner, small	7·34	—	—	13·65	0·538	
	,, ,, medium	19·68	—	—	24·2	0·742	
	,, ,, large	25·2	—	—	44·1	0·567	
	Argand Burner ...	38·5	—	—	21·7	1·268	
	Incandescent Auer Burner	77·0	—	—	14·85	5·68	Upright.
	,, Olso ,,	120·0	—	—	23·7	5·06	Large burner.
	,, Krämer ,,	55·4	—	—	11·62	4·76	Small ,,
	,, Inverted ,,	12·75	—	—	4 18	3·05	Large ,,
	,, ,, ,,	62·4	—	—	9·84	6·35	Small ,,
	,, ,, ,,	32·4	—	—	4·81	6·74	
Acetylene	Flat Flame ...	27·5	—	—	4·41	6·23	
	Incandescent ...	32·6	—	—	8·22	3·97	
Electric Glow Lamps	Carbon Filament Glow Lamp, 16 H.K.	19·9	0·1243	18·5	0·230	86·5	
	,, ,, 25 ,,	26·9	0·174	22·4	0·390	57·4	
	,, ,, 25 ,,	31·9	0·18	23·8	0·428	74·5	Perpendicular to plane of filament
	,, ,, 25 ,,	25·95	0·18	21·6	0·389	66·7	Parallel ,, ,,
	,, ,, 32 ,,	43·5	0·195	24·2	0·472	92·4	
	,, ,, 50 ,,	65·2	0·234	28·0	0·6552	99·4	
	,, ,, 100 ,,	144·0	0·30	40·9	1·228	117·2	
	Tantalum Lamp ... 25 ,,	41·8	0·042	51·0	0·214	195·5	Metal filament glow lamps.
	"Zirkon" ,, ... 35 ,,	46·2	0·043	57·8	0·2485	185·5	
	Osram ,, ... 32 ,,	39·8	0·036	59·2	0·213	186·8	
	Wolfram ,, ... 50 ,,	63·7	0·05	58·0	0·290	219·5	
	"Colloid" ,, ... 25 ,,	37·1	0·03	46·6	0·1399	265 0	
	Nernst (without globe) ...	18·6	0·471	1·019	0·0480	387·5	Filament horizontal small burner.
	,, ,, ...	62·0	0·874	1·53	0·1338	464·0	,, vertical ,,
Electric Arc Lamp ...		—	—	—	—	cca. 3000	
		Total Light Radiated.	Dimensions of Opening.	Temperature.	Intrinsic Brilliancy.		
Glass Furnace (heating flame and glowing interior)		4,685	24 × 26 c.m.	1223°	624	7·52	
		1,075	,,	1129°	,,	1·72	
		522	,,	1026°	,,	0·836	

is not so extremely severe as might be expected. In gazing direct at such a source it is literally impossible to maintain the eye in such an immovable condition that the image of the filament is retained throughout the period of fixation on exactly the same position on the retina. The image is always slightly altering its location, and the exhaustion of visual material is thus spread over a larger area. Were this not the case a permanent injury to the retina would follow after a very short interval. In this connexion it may be added that the after-image of the glow-lamp filament appears as a line of far greater width than that which the actual diameter dimensions of the filament would suggest. Owing to these facts we find that the glaring effect does not increase proportionally with the intrinsic brilliancy.

Finally we may inquire how far the degree of glare of an illuminant is dependent on the distance of the source from the eye.

Two sources of light of equal intrinsic brilliancy and equal intensity in general appear to the eye equally glaring at different distances away (such as 5 or 20 metres), in a clear atmosphere. One can best observe this fact by looking at a long row of incandescent gas lights in the street on a clear evening. The first lantern looks almost exactly as bright as the most distant one, though the latter only appears to the eye as a luminous point. It would therefore seem that the intrinsic brilliancy of a surface is a quantity which is independent of distance. It is only in the case of great distances, as a rule, that the effect of atmospheric absorption has the effect of reducing the intensity of the retinal image. At the same time the fact that the retinal image occupies a smaller area tends to give rise to somewhat less glare. Under practical conditions, however, and within wide limits we may say that the glare of an illuminant is practically independent of its distance from the eye.

Dazzle is also, strictly speaking, practically independent of the brightness of the surroundings. Yet it must be admitted that the eye tires more rapidly when exposed to a bright light with a black background than when exposed to the same source, with a moderately illuminated surface behind it. This may perhaps be due to the fact that the eye is involuntarily attracted by a bright object in dark surroundings, and the retinal image is therefore confined to a very restricted portion of the retina; but there is not this impulse to steady vision in one direction when the contrast is less. In addition the wandering of the eye from brightness to darkness gives rise to pupillary fluctuations and sudden alterations in the condition of adaptation which are in themselves responsible for fatigue. These two causes are probably the sole explanation of the intolerable and fatiguing effect of a source of light of an unsteady and flickering character. From the hygienic standpoint one cannot sufficiently insist upon the objectionable nature of such sources of light.

The sharp shadows which are caused by sources of light of small dimensions are naturally in no wise responsible for glare. On the other hand, as explained above, the rapid adjustment of the pupil and the retina which take place as the eye roves from a dark surface to one very much brighter in themselves constitute a source of fatigue; therefore such a "hard" system of illumination is apt to be wearisome. Abrupt changes from light to shade are therefore undesirable and can be avoided by surrounding such point-sources by a thick opal globe which appears evenly illuminated and therefore both reduces the intrinsic brilliancy and softens the shadows. Even this system is open to objection from the hygienic standpoint, because the direct shadows from such a single source are still often so obscure that the eye can discern nothing in the portion of the surroundings covered by them. Moreover, such shadows appear black, and not the colour of the object itself as in the case of diffused daylight. In artificial illumination it is often desirable to imitate daylight conditions by the use of a number of subsidiary lights of smaller intensity which illuminate the deep shadows

caused by the main source. In interiors one may profitably arrange the main source in the middle of the room near the ceiling, and the smaller sources round the room, on the cornices, &c. The same result is very simply secured by the semi-indirect system of lighting, where the deep direct shadows are relieved by the reflected light from the ceiling.

Query 5. We are next faced by the question how to determine whether or no a source of light is absolutely and permanently dazzling, according to the above definition. Unfortunately it must be confessed that there does not seem as yet to have been any even approximately exact method of deciding this point devised. Until recently there was no need for it, and the engineer concerned with lighting questions seems to have been content to ignore these physiological aspects of the matter. The oculist, on the other hand, whose co-operation might lead to the working out of such a method, has also hitherto concerned himself but little with practical problems of hygienic illumination, and usually possessed but little technical knowledge on the subject. Hence it is only by the efforts of the illuminating engineer, whose object it is to bring to bear on this question the combined resources of the engineer and the physiological expert, that progress in this direction might be anticipated.

The opening and closing of the pupil-aperture, which take place as a result of changes in the flux of light entering the eye, seem to me but ill-adapted as a means of estimating glare. The contraction of the pupil is only in a secondary sense a protection against permanently dazzling conditions; it is mainly intended to protect the eye temporarily, and only continues until the pigment has spread out, and the eye has adapted itself to the changed conditions. It is only when the flux of light entering the eye is so great that the upper limit of adaptation is about to be exceeded that the contraction is permanent; otherwise the aperture gradually enlarges to its former state as the adaptation of the eye progresses.

In addition Widmark and Sachs have pointed out that the contraction of the pupil-aperture is extraordinarily dependent on the spectral composition of the light entering the eye. The rays of long wave-length and the infra-red rays appear to exercise the most marked effect upon it. In the visible spectrum the red is the most influential, and the effect becomes less marked as we approach the violet. Finally we observe that the ultra-violet rays are almost without action at all.

Moreover, it must also be noted that the opening and shutting of the pupil-aperture is essentially a subjective test, and is not only a somewhat variable quantity in the case of any one individual, but also manifests itself very differently in the case of different races of people. It appears to be directly connected with the pigmentation of the eye. Northern people have, as a rule, retinæ which are light in tint, and a small pupil; inhabitants of southern races, on the other hand, usually have large pupils and strong pigmentation.

From these considerations I draw the conclusion that it would probably be misleading to rely upon the pupil-contraction as anything but a very approximate indication of the existence of glare. The "blinking of the eyes" has also been suggested as an indication in this direction, but this again is open to many objections similar to those urged against the observation of the pupil-orifice, and is affected by many outside conditions which have little bearing on the question of glare. The blinking of the eyes of cats, for example, is to be regarded merely as a symptom of general fatigue.

On the other hand there does seem to me a possibility that a closer study of the range of adaptation of the retina, its connexion with intensity of the light entering the eye, and especially the formation of after-images, might open up a serviceable physiological method of detecting glare. The greater the degree of dazzle the more rapidly is the visual material used up, and the upper limit of adaptation exceeded; the more permanent, therefore, the after-image. Hence it might be suggested that the time which elapses

before the after-image becomes visible, and the duration of time for which this after-image persists with the closed eye, would form the best physiological criterion regarding the extent of the glare. In order to obtain reliable figures for the effect of any source of light it is necessary to take the mean of a large number of observations in order to reduce the influence of subjective errors and abnormalities to a minimum. As an example of such results it may be stated that the after-image of a petroleum lamp, the intrinsic brilliancy of which was 3·69 H.K./square cm., persisted for about three minutes, while that of a carbon filament glow-lamp having an intrinsic brilliancy of 66·7 H.K./ square cm. lasted for as much as twenty minutes. I hope on another occasion to give a more detailed description of my experiments on the appearance, persistence, and gradual passing away of images of various sources of light.

In the same way, it may be said, with perhaps even greater certainty, that no really serviceable means of measuring the glare due to the invisible ultra-violet rays exists. The suggestion regarding the value of observation of the duration of the after-images is clearly not applicable in this case. If we had even a satisfactory means of quantitative estimation of the effect of the ultra-violet rays this problem would not be so difficult. This last subject, however, is still in an extremely debatable stage, and on this, too, I hope to be in a position later to make more definite recommendations.

(*To be continued.*)

Prof. L. Weber (Kiel).—In my opinion it is very desirable that there should be some limit to the brilliancy of lights in interiors, and for the maximum hygienic intrinsic brilliancy I should be inclined to specify that of the ordinary candle-flame, namely about 0·4 candles (Hefner) per sq. cm.

A system of illumination may be described as "glaring" when it exceeds any of the limits specified in the following :—

(*a*) If the ratio of the intrinsic brilliancy of the source of light to that of the illuminated surroundings exceeds a certain limit. This ratio should not exceed a value of about 100.

(*b*) If the absolute intrinsic brilliancy of the source exceeds a certain value. As mentioned above the brilliancy of the open candle-flame might be taken as the safe limit.

(*c*) If the angle between the direction of vision of the eye when applied to the work it is called upon to do (*e.g.* when gazing at a desk, blackboard, or diagram on the wall, &c.), and the line from the eye to the source of light, is too small. This minimum angle might be provisionally assumed to be 30 degrees.

(*d*) When the extent (apparent area) of the illuminating body is too large. The source should not subtend an angle of less than 5 degrees at the eye.

It may be added that of these conditions *a* is by far the most important. The number 100 is founded upon the conditions prevailing in a normal interior illuminated by light from the blue sky. Under such conditions I assume that the eye will not be dazzled when the gaze is turned away from the interior of the room and directed towards the sky. Now the intrinsic brilliancy of the sky is about 8,000 secondary Hefner units = $\frac{8,000}{\pi.10,000}$ = 0·25 primary units.* The intrinsic brilliancy of the white surfaces illuminated by the sky in the room under these circumstances will usually be about 0·0025 primary units (Hefner candles per sq. cm.). The ratio of this to the former quantity is just about 100.

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* The definitions of the primary and secondary units of intrinsic brilliancy or surface-brightness (Flächenhelle) are as follows:—

1 Primary Unit = the intrinsic brilliancy of a surface such that one square centimetre of it yields a light one candlepower (Hefner).

1 Secondary Unit = $\frac{1}{\pi.10000}$ primary units and represents the degree of intrinsic brilliancy of a white matt surface, of albedo unity, which receives an intensity of illumination of one metre-candle (Hefner).

INTRINSIC BRILLIANCY OF VARIOUS SURFACES.

(See Weber, Zur Frage der Lichteinheiten, Schilling, *Journal f. Gasbeleuchtung*, &c., 1888, p. 597–604.)

NATURE OF SOURCE.	INTRINSIC BRILLIANCY. Primary Units.		Secondary Units.
1. Solar Disc (Sonnenscheibe)	Green ...	171,700	5,394,000,000
	Red ...	64,400	2,025,000,000
2. Sky near position of sun	Green ...	20·40	640,900
	Red ...	15·75	494,800
3. White cardboard received illumination from the unrestricted sky, Breslau, 12 o'clock, June 12, 1885	Green ...	6·01	189,100
	Red ...	2·17	68,310
4. White clouds	Green ...	1·81	57,040
	Red ...	0·33	10,390
5. Albocarbon flat-flame burner, seen edgeways	Green ...	10·4	326,200
	Red ...	9·7	304,500
6. Albocarbon flat-flame burner, seen broadways	Green ...	1·50	46,790
	Red ...	1·40	43,680
7. Argand burner	Green {	0·895	28,150
	Red		
8. Blue sky at angle of 60°, sun at Zenith ...	Green ...	1·04	33,000
	Red ...	0·12	3,800
9. White card illuminated by the unrestricted sky at Breslau, 12 o'clock, Dec. 23, 1884	Green ...	0·062	1,945
	Red ...	0·016	508
10. Black velvet illuminated under the same conditions as the preceding 3	Green ...	0·012	378
	Red ...	0·0044	137
11. White cardboard so illuminated that print upon it can be read with ease	Green ...	0·000,318	10
	Red ...	0·000,318	10

Point *b* is also founded on actual experience. We know that a candle-flame in a reasonably well-lighted room is not unduly glaring.

Points *c* and *d*, however, are only roughly estimated, and to be regarded as of a suggestive character.

As a consequence of the important proposition *a* it may be pointed out that multiplication of the sources is desirable. Thus two candles will give rise to less glare than one, if they form the sole method of illuminating an interior, simply because the intrinsic brilliancy of the surroundings will be increased thereby, while the intrinsic brilliancy of the sources remains the same. In fact, the ratio referred to has been reduced by one half. In the following table are given some values of the intrinsic brilliancy of different luminous objects expressed in both primary and secondary units.

Dr. M. Corsepius (Cologne).—A complete answer to the series of queries on the subject of glare is hardly possible, especially as concerns numerical results, owing to the number of different factors involved. The following comments on some of these questions may, however, be of interest :—

No. 1.—Intense contrast of light and shade ; the actual amount of light given by a source is only of secondary importance in this respect.

No. 2.—See additional remarks at end.

No. 3.—Modern sources of light ought never to be protected only by clear glass.

No. 4.—In general one cannot specify exact figures for the permissible degree of glare. This depends very greatly on the surroundings, and on the way in which shadows are formed. The multiplication of sources of light and the placing of them at a considerable distance from the eye are effectual methods of reducing glare. Fluctuations in intensity tend to accentuate the inconveniences of glare.

Nos. 5 and 6.—I consider photographic methods practicable. According to such tests the image of the surroundings of a bright source of light should also be discernible when the source of light itself is sharply outlined on the plate.

No. 7.—The effect of various colours is not the same. The red light of some flame arc lamps is especially objectionable, though innocuous if the lamps are properly arranged. The effect of ultra-violet rays does not enter into this question.

No. 8.—If the lamps are hung high enough and effectually screened—no! The use of intense beams of light on rapidly travelling vehicles constitutes an undoubted but apparently inevitable evil.

No. 9.—The use of frosted glow-lamps, installed "house-high" may be advocated.

No. 10.—Certainly. But in general only questions of contrast and glare due to direct reflection are of interest from the architectural standpoint.

Additional Comments.

The normal human eye is adapted to withstand wide variations in intensity. On the other hand, fluctuations of light and darkness (whether in space or time), are objectionable. For example, when one travels into mountainous districts or into Italy, the enormous increase in the brilliancy of the illumination does not produce any ill effect. But when the ground is covered with snow, or even light grey in texture, one is dazzled, because the reflected rays of light enter the eye from below. One should, therefore, aim at placing sources of light high up.

One's eye is dazzled even by the light of a match, when struck in the darkness. In this case it is the *contrast* which is responsible. In the same way one can observe, without inconvenience, an osram lamp of several hundred candle power, when surrounded by opal glass, whereas a corresponding lamp with a clear glass globe dazzles.

One should, therefore, take pains so to place our lights that, in going about our daily business, we are not dazzled by receiving their direct rays. The greater their brilliancy, the higher and more distant from the eye should they be placed. Clear glass lamps should, above all, never be used unscreened. Frosted lamps, placed near the ceiling, achieve their purpose much better, and low-hanging "advertisement lamps" are a nuisance.

An interesting example of interior-lighting is furnished by the Königl. Maschinenbauschulen, in Cologne. Before the erection of some new building a series of experiments were made, with the object of securing a uniform, shadowless, and steady illumination. At that time there were no tungsten lamps available, and Nernst lamps were decided upon. In order to avoid any possibility of dazzle and also to produce a uniform illumination the arrangements shown in Fig. 1 was selected. Below the lamp were placed semi-transparent opal glass shades; above clear glass. The resulting illumination was both uniform and soft. Eventually, however, the intensity of the Nernst lamps feel off, and it was found desirable to replace them by tungsten lamps. At the present time the arrangement has, therefore, been altered to that shown in Fig. 2. Each 110 Watt Nernst lamp has been replaced by a 75 H.K. Osram lamp, having a frosted bulb, and without any reflector. These lamps were originally hung as low as the Nernst lamps had been, but subsequently the cord was shortened so as to bring them nearer the ceiling, as indicated in Fig. 2. Measurements showed that the brightness of the illumination on the tables, &c., in the room had not been reduced, in spite of the increase in their height, the illumination being to-day one and a half times that previously obtained. On the other hand the effect on the eye is very satisfactory, and there is no trace of dazzle.

From this example we may draw the deduction that it is not necessary to take any extravagant precautions to avoid the glare. If the lamps are frosted and placed near a white ceiling their brilliancy is not offensive and the reflected light from the ceiling and light walls renders the illumination practically independent of the height of the illuminant.

FIG. 1.—Room lighted by Nernst lamps, opal diffusing surface below, and clear glass above.

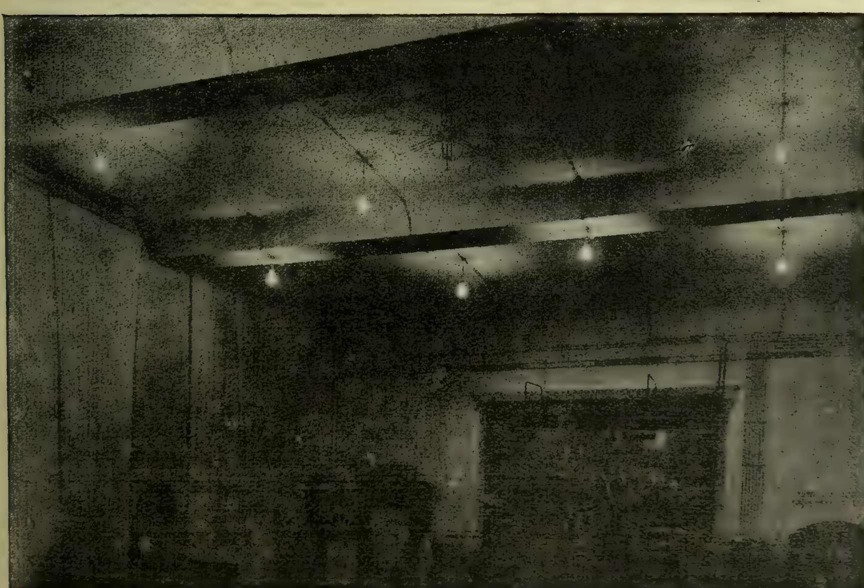


FIG. 2.—Same Room lighted by Frosted Tungsten lamps, hung high up.

These two photographs serve to illustrate how the conditions demanded in Queries 5 and 6 may be secured. I consider ceiling-illumination with glow-lamps a very serviceable method when enough light is used. It may be recalled that, owing to the narrow shape of metallic filament lamps, comparatively little light is thrown directly downwards or even at small angles to the vertical. It is, therefore, advantageous not to employ too opaque a system of frosting. I consider, however, that the method occasionally adopted hitherto, of only frosting the lower portion of the lamp is, as a rule, unsatisfactory. Only completely screened lamps should be used, except in special cases (*e.g.*, when suitable reflectors are employed) in which it is impossible for the eye, looking in any direction, to receive light direct from the glowing filaments.

Dr. L. Bell, Boston—Among the very interesting queries on the list, numbers 3 and 8 appeal to me as of special practical importance. I believe that I am responsible for the suggestion that it is unsafe to go above 5 candle-power per square inch in intrinsic brilliancy, this suggestion having been made some half-dozen years ago in a paper before the American Institute of Electrical Engineers. As a result of close observations since that date, I am strongly of the opinion that 5 candle-power per square inch is too much for near sources, while for distant sources, as found in large spaces and out-door work, it can easily be tolerated. With respect to the ill-effects of too much intrinsic brilliancy in the source, it is my opinion that the liability to trouble (assuming the lights to be steady), depends ultimately on the total amount of energy concentrated in the image. In other words, for steady lights of similar colour the photo-chemical action on the retina is a question of the ergs per second. The effect practically depends, therefore, not only on the intrinsic brilliancy of the light emitting surface, but also on the absolute amount of energy that reaches the eye. An arc lamp in an opal globe, for example, presenting an intrinsic brilliancy that would be intolerable in a small room becomes entirely inoffensive on the street.

I find by experience that for ordinary lamps an intrinsic brilliancy of 1 candle-power per square inch, obtained, for instance, by screening the tungsten lamp in an opal globe, is absolutely inoffensive, and I think the practical maximum allowable for interior work would be found somewhere around 2 or 2½ candle-power per square inch. This is substantially the limit indicated by me in a paper on ‘ The Physiological Basis of Illumination ’ a couple of years ago. In larger spaces the maximum may be increased somewhat.

The last section of Question 3 introduces an entirely different element, that of *contrast* as related to the adaptation of the eye. One may look at the matter from the physiological standpoint somewhat as follows :—The work thrown upon the retina in visual processes depends upon the rate at which the photo-chemical changes are compelled to go on. A bright image on the retina produces certain changes from which recuperation takes place when the stimulus ceases. If stimuli succeed each other rapidly, either owing to fluctuations of the source, or shifting of the position of the image on the retina, the work demanded of the retina, as a whole, increases ; and in addition there is extra labour demanded of the pupillary mechanism and frequently of the accommodation ; all these may make a total sufficient to overload the organ and produce fatigue. One finds, as a result, that a slow flicker, even of rather moderate amount, becomes distressing after a very short period, and its evil effects disappear only when the successive stimuli follow each other at a rate which is well under the reaction times of the various elements in the organ.

Moreover, when a fairly brilliant source is placed in well-lighted surroundings, the eye gets down to a relatively settled state and its efforts to accommodate itself to new conditions impose less strain. As a tentative hypothesis, I would suggest that the most important consideration is quite likely to be the difference in intrinsic

brilliancy between the illuminant and its surroundings, which measures, in a way, the change in activity required when the bright image shifts its position (as it is constantly doing in ordinary vision). Much, of course, depends on the state of adaptation of the eye, which seems under each new state of illumination to gradually settle itself to a new condition of equilibrium.

With respect to the intrinsic brilliancy of the sources used in the streets, the arc lamp with clear globe, as very largely used in the United States, is rather bad. When opal enclosing globes are used, I do not think that the intrinsic brilliancy often rises too high, especially when the lamps are hung 25 or 30 ft. above the street. It does become offensive, however, when flaming arcs are used at a short distance above the sidewalk, as they too often are, the energy received by the retina then becoming painfully great. We are gradually introducing opal-shaded street arcs in this country, with extremely good results. Motorists in particular find the change very beneficial, and while the lights give less candle-power, owing to absorption in the globe, there is general agreement that they give very much better *illumination.*

The trouble hinted at as arising from the enormous glare from the head-lights of motor-cars is a serious one. I can hardly give better evidence of the trouble caused to motorists by an unshaded arc hung rather low, than by citing an accident which happened in the suburbs of Boston a short time ago, in which two motor-cars, each provided with the ordinary head-lights, met in a head-on collision immediately under an arc lamp, both drivers being dazzled by the glare and unable to see well enough beyond it to judge their distances properly. The glare from the head-lights of motor vehicles has proved itself a serious obstacle to traffic. The effect of the concentrated beam is dazzling in the extreme, and correct judgment of distance in its presence is very difficult. A similar difficulty has been encountered in some American towns, owing to the frequent use of arc-light head-lights of great power on fast electric cars. In some cases towns have found it desirable to forbid the use of these glaring lights within their more densely populated portions, and in such cases it might prove feasible to cut down the head-lights of motor vehicles by shutters, in running through towns where the speed limit is moderate and consequently the far-reaching beam is unnecessary for safe driving.

Dr. E. P. Hyde, Cleveland, Ohio, U.S.A. — The entire subject of "glare" is one in which the laboratory of the National Electric Lamp Association is intensely interested. I therefore conferred on the subject with my colleagues, Dr. Ives and Dr. Cobb (who is the physiologist of the laboratory). As a result of that conference we performed a few simple experiments, the results of which, together with a general statement giving our present view of the subject, I beg to submit as a part of the discussion.

It must be borne in mind that the following contribution is made with only a day's thought and only a part of a day's work, in order to be in time for presentation at this meeting, and therefore our statements are submitted rather as suggestions for further consideration than as definite conclusions. Probably the results of more elaborate investigations on similar lines will be presented subsequently.

In considering glare (where by glare we mean a sensation of light which is painful or uncomfortable), it is necessary to discriminate between sources of different size. Sources which are too large to be considered points or lines, but which are still of small dimensions, may, at moderate distances, produce images on the retina which are more extended than they should be, owing to scintillation, just as in the extreme case an object looked at across a hot surface is seen with very hazy outline. In addition the size of images of very small bright objects is affected by diffraction at the rim of the pupil of the eye. Moreover, it has been shown, I believe, that the eye is continually in motion, and this seems to be also a possible source of diffusion

of the image when small intense sources are viewed.

With sources of moderate size, there would seem to be three elements to be distinguished. In treatises on optical systems such as Chapter 4 of Drude's 'Lehrbuch der Optik,' it is shown that if there is no light lost by absorption or reflection, and if the refractive indices in the object and image regions are the same, the theoretical intrinsic brightness of the image is equal to that of the object. As Drude points out, however, this theoretical intrinsic brightness, which refers to the normal emission per unit area, must be distinguished from the intensity of illumination of the image actually formed on the retina. This can be increased tremendously by increasing the aperture of the emergence pupil, while intrinsic brightness is independent of aperture.

In the case of subjective brightness, we are concerned with the intensity of illumination of the retina rather than with the intrinsic brightness of such an image as that defined by Drude. It is true, however, that if there is no auxiliary optical system, and if the pupil of the eye maintains a constant aperture, these two quantities, the theoretical intrinsic brightness and the actual intensity of illumination of the image, are proportional and are not affected by distance from the source.

A third quantity to be considered is the area of the retina excited, and it would seem that this plays an important role in determining glare under some circumstances. We hurriedly performed the following experiment: A Nernst glower was focussed by a lens on the pupil of the eye. An adjustable iris diaphragm was mounted in the optical plane of the lens, and the eye was focussed on the diaphragm. (An artificial pupil, of smaller diameter than the pupil of the eye, was used so that alteration in the pupil-aperture would not affect the experiment.) By varying the opening of the diaphragm the area of the image on the retina was increased, but neither the intrinsic brightness nor the intensity of illumination of the image on the retina was changed. The difference in glare, however, when the diaphragm was closed down and when it was open was most pronounced. It was possible with moderate openings to look with perfect comfort at the diaphragm, but when the latter was open to its full diameter the glare was almost unbearable. This experiment shows at once that, other things being the same, the size of the illuminated area of the retina has a marked influence in determining whether or not a certain illumination is glaring.

When the same experiment was repeated without the artificial pupil the same qualitative results as to glare were obtained, though it is quite possible that in this case the pupil of the eye may have changed. (If there were such a change we would expect it to be in the direction of *reducing* the glare from the large source by reducing the intensity of illumination of the retina.)

It would seem that this experiment reproduces an effect essentially the same as that which is observed in the case of ordinary illuminants placed at different distances. It is quite possible to look at incandescent filaments across a room or at the crater of an arc in the street without being sensible of the very intense blinding effect which is experienced if we look at either of these at sufficiently close range. Since (except for the change in the pupil, which, as we have seen, would tend to decrease rather than increase the glare on close approach to the source, and except possibly for scintillation), the only effect of approaching the source is to increase the total flux of luminous energy into the eye by increasing the area of the retina excited.

In order to determine whether the total flux of light entering the eye is the main factor responsible for glare, we also tried, somewhat hurriedly, another experiment. The crater of an arc was focussed on an opal screen which gave moderately good diffusion in transmission. By moving the arc and condensing lens, with reference to the eye, and keeping the opal glass fixed, it was possible to vary the size of the image on the diffusing screen.

The total flux of light entering the eye under these conditions remained approximately so ; yet, while no very disagreeable sensation was experienced when the arc was considerably out of focus, there was an appreciable glare when focus was secured. From this experiment it would seem that the total flux into the eye is not the only element entering, but that the intensity of illumination plays some part. The effects of altering the size of field retaining the intensity of illumination at a constant value, and of varying the intensity of illumination with a constant size of field, are questions which would be very interesting to investigate. We hope shortly to pursue this investigation in this laboratory.

In considering glare it seems important to keep in mind the adaptation of the eye, both of the retina and of the pupil. An illumination which may appear glaring when the eye has been adapted to darkness may produce no discomfort when the eye has been accustomed to moderately intense illumination. Finally, we should like to learn more as to the effect of bright objects which are within the field of view, and therefore form images on the retina, but which do not receive the attention of the observer. If our eyes are directed towards a relatively dark object (which would demand a large aperture of the pupil) it would be natural to expect that brightly illuminated objects within the range of vision would produce discomfort.

Prof. R. Ulbricht, Dresden.—I should like to point out that it is incorrect to suppose, as many people seem to do, that a uniform soft system of illumination and the complete avoidance of visible bright sources constitutes the ideal form of artificial illumination. For special purposes such a method may, of course, be desirable. But in ordinary circumstances, an illumination due to a number of bright objects is to be preferred in my opinion to purely diffused light, provided that intensely sharp shadows are avoided. In recommending this method I assume a light of good quality from the hygienic standpoint. The eye will receive the stimulus of brightness and it will also be provided with darker surfaces on which to rest, as in the case of natural illumination. Under such conditions one may justifiably utilise surfaces having a higher degree of brightness (*i.e.*, surface-brightness or intrinsic brilliancy) than in a workroom, where the eye does not rove about but is continuously turned in a certain direction. While in the last case an intrinsic brilliancy of 0·1 H.K. per square centimetre may be prescribed, under the first-named conditions as much as 2 H.K. per square centimetre might be regarded as by no means excessive.

Dr. L. Bloch, Berlin.—My remarks refer chiefly to Queries 3, 8, and 10.

There can be no doubt that, in interiors at least, the arrangement of the sources of light should be such that the eye is never compelled to look straight at an unscreened bright light. Apart from the candle, the oil-lamp, and the flat-flame gas burner, all our modern sources of light have, in the unscreened condition, a degree of brilliancy which it is bad for the eye to perceive directly, and which may be injurious in the case of long exposure.

Still, it would, in my opinion, be going much too far to insist that unscreened sources should under no circumstances be employed in interiors. But we should invariably make use of diffusing screens and globes in all cases in which the lights, owing to their position, are apt to fall within the direct range of vision (for example, in the case of low-hanging fixtures and chandeliers such as are used in many large rooms).

In the case of electric glowlamps, particularly metallic filament lamps, the method of screening involving the use of suitably designed outer globes is distinctly preferable to the usual method of frosting the bulbs. Frosting is known to diminish noticeably the useful life of the lamps, whereas the use of outer globes, on the other hand, protects the lamps and rather tends to increase their useful life. When the lamps are placed high up near the ceil-

ing, however, it is often not necessary to screen the lamps, and this system of lighting is particularly to be recommended in the case of metallic filaments. In the case of rooms with light walls and surroundings ceiling-illumination can be satisfactorily employed, and demands almost the same consumption of electricity as the hanging of lamps on fixtures at a lower level.

A fundamental means of avoiding glare in interiors is inverted illumination. This, however, cannot be approved without reservation. As regards expense it may be admitted that a room with white ceiling and walls can be illuminated by inverted system at not much higher cost than in the case of direct systems of the ordinary kind. But inverted illumination has not always had the result anticipated. Owing to the absence of any visible source, the resulting illumination appears somewhat "cold," and the complete absence of shadows is also often unsatisfactory, especially as regards its effect on architectural impressions, the display of furniture in a room, &c. On this account a semi-inverted system, which softens the light and yet permits a certain amount of direct lighting, is to be preferred.

The illumination of streets and public lighting must naturally be considered in quite a different manner to indoor-illumination. Here, in spite of all physiological and hygienic considerations, and in spite also of the very considerable intrinsic brilliancy of many of the sources employed, a certain degree of glare is often desired. For example, notwithstanding their greater intrinsic brilliancy, the Nernst lamp and the metallic filament lamps have appealed to the public for street-lighting more successfully than carbon filament lamps ; in the same way small arclamps of yet greater intrinsic brilliancy are preferred by many to tungsten lamps giving the same candle-power. No doubt this may be partly ascribable to the whiter character of the light, but it is mainly evidence of the desire for more "brilliant" illumination. How far the taste in this direction can go is illustrated by the system of street-lighting in Berlin, where high pressure incandescent gaslamps of 3,000 to 4,000 H.K., and with clear globes, are installed at a height of only 5·5 metres ; although, under these conditions, the light must stream direct into the eyes of passers-by, very little complaint has been heard from the general public regarding the matter. A great deal of educational effort is needed before the general public comes to realize the fact that a glaring system of illumination is not the best for the eyes or for clear vision.

The habit of installing powerful sources of several thousand candle-power directly in front of show-windows and at a low height is quite indefensible, on account of the needless, irritating glare thus caused. Unfortunately, examples of this method are now to be met with very frequently in the chief streets of most large cities. One cannot sufficiently or energetically condemn this habit, and it seems to me very desirable, in the interests both of the owner of the premises and the contractor responsible for such installations, to take every opportunity of impressing upon them the fact that they are utilizing an absurd and uneconomical method of lighting.

M. Lauriol (Paris).—I find it difficult to quote precise figures bearing on this subject. The effects of glare are experienced so differently by different people. For example, some of my friends prefer an opal screen for a reading lamp, but I myself could not tolerate a system which allowed any direct light from the source to strike the eye. I therefore use an opaque paper screen with a dark tinted exterior, but white inside. Under these conditions one's face and eyes are in the shade and one sees only the illuminated object and nothing of the source itself. In my opinion, therefore, the desirable maximum limit of intrinsic brilliancy of a source, from the hygienic standpoint, would be zero.

However, there are considerations which limit the possibility of reproducing this arrangement in practice.

(1) When a general illumination has to be produced for the benefit of a number of people in a street or room, it is almost inevitable that some rays coming straight from the source should reach the eye. We ought, however, by suitable diffusing screens to cut down their intrinsic brilliancy as low as possible, and to place the sources high up, or to employ the indirect method of throwing light on to a white ceiling.

(2) Although this method of producing a subdued illumination may be desirable from the hygienic standpoint, and may answer in an office or at a scientific meeting, it may not be equally acceptable at a pleasure-gathering, where something more stimulating and festive is required. In such cases we must not press the claims of subdued illumination too strongly.

There are many respects in which the existing methods of illumination in the streets, &c., might be improved. Many shops make use of powerful unscreened lamps placed at a very low level of say 2 to 3 metres above the ground. Such a method is very tiring to the eye, and is probably of little use as a means of displaying the goods in the window. It is only a violent attempt to attract the attention of passers-by. Ought it to be forbidden? Perhaps so. But it is difficult to advocate legislation on this point. It may be added that the rules for street lighting, both by gas and electricity, in Paris, are very similar to those in force in London, and there is not much prospect of any immediate change.

Professor S. A. Rumi, GENOA.—I understand by a "glaring" system of illumination, one in which unscreened powerful sources of light of concentrated brilliancy — such as arc lights, incandescent gaslights, and metallic filaments—are used, but are not provided with suitable diffusing globes. In addition, many sources, which, in themselves, might not be considered glaring, become so when used with a concentrating lens or concave reflector directing an intense beam in a certain direction.

The eye is greatly affected by looking for a short time at such illuminants, and its powers of vision are temporarily diminished, even when the eye is withdrawn and directed towards less brilliant surroundings.

The tendency towards high temperature of incandescence, and the consequent concentration of the light over a small area, which is typical of the more efficient recent illuminants, is therefore prejudicial to eyesight, and also the habit of using these lamps, without an adequate screen, at too low a height from the ground. In such cases the eye is unfortunately involuntarily attracted towards the luminous object. The contraction of the pupil-aperture, and its subsequent readjustment when the eye is directed elsewhere, are a source of fatigue to the eye. Moreover, the retina is also inconvenienced, and it is a well-known fact that "after-images," arising from the circumstance that the retina does not immediately return to its normal condition after exposure to a light object, are more or less severe according to the brilliancy of the object observed. The sudden formation of a very bright image on the retina can be compared with a severe physical shock, a single instance of which may be unpleasant, but not irremediable, while a repetition is undoubtedly injurious. These considerations seem to justify the recommendation to limit the brilliancy of unscreened sources exposed in interiors; but it must be noted that the question can really only be determined by tests of a *subjective* character and not objective ones.

In general, a system of lighting approaching to natural illumination is to be desired, and extreme contrasts avoided. According to my experience, the system of strongly illuminating the table at which one is seated, and leaving the rest of the room in comparative darkness, is to be avoided, especially when the table is covered with a white surface and the light is concentrated upon it by means of opaque reflectors. As a rule, the best illumination from the hygienic standpoint would probably be secured by aiming at a considerable number of sources of low brilliancy

rather than a few concentrated lights, and by placing such lamps high up, out of the range of view. It is a good plan to diffuse the light over the lower hemisphere by the use of frosted glass, allowing the light from the upper unscreened portion to be reflected and diffused by the ceiling (which should be of a white colour). Many examples of this system are now to be met with in our buildings and invariably give satisfaction.

Dr. W. H. Seabrook, New York.—I should define glare as a dazzling effect produced upon the retina by too brilliant a light. Accepting this definition, the factors affecting the production of glare would be the intrinsic brilliancy of the light, its distance from the eye, and the character of the eye itself.

Chemical light is absorbed by the animal lens before it reaches the retina; the amount of absorption varies in different species and individuals. Too strong a light injures the lens, and cataract may be produced by the ultra-violet rays in case of great intensity of the light and exceptional length of exposure. Contraction of the pupil lessens the amount of light reaching the retina, but does not protect the centre of the lens. The "glare" is modified by the absorption of light by pigment cells in the retina. Hence the sensation of glare is not an adequate guide as to the danger of injury to the human lens from light. While no eye should be exposed to an illumination of more than two candle-power for any length of time, the minimum is not so easily determined. One has only to take the well pigmented eye of an elderly person of the so-called far-sighted type, who is not properly supplied with glasses and has a chronically contracted pupil arising from the habitual use of strong light, and compare it with the eye of a near-sighted blonde with large pupil, having no proper contractile power, to see that illuminating engineers can hardly hope for specific answers from oculists based upon what the laity describe as the "normal eye." (Which reminds me that an important method of protection from glare in the last-described class of eye is "narrowing of the inter-palpebral aperture," or, as the ordinary American puts it, "squeezing the lids.")

An answer to the first portion of question (2) would seem to require a volume by itself. Injuries to eyes from too brilliant light might be divided into two classes, organic and functional. The organic injuries may again be divided into those resulting in permanent defects and the more numerous variety, where there is recovery some months after the exposure. One type of injury usually resulting in permanent damage—that due to direct exposure of the eye to the sun (as in viewing an eclipse) without proper precautions, could, perhaps, hardly be described as coming from an injudiciously placed source of light, but electric light amaurosis is sometimes permanent and might be so described. Functional cases of injury sometimes lead to temporarily impaired vision as well as pain and discomfort.

As regards the latter part of question (2), we enjoy in America very good school illumination in primary and public schools. The hours of study end early in the afternoon and daylight is employed. In our so-called preparatory schools, on the other hand, the lighting is usually very bad for night work, incandescent electric lights being placed in front of the student over a desk. Gladys Black, of the Physical Education Society, has shown that lateral curvature of the spine results in some public schools from a twisting of the body to avoid sunlight being reflected into the eyes. Dr. Fuchs, now of Vienna, stated a quarter of a century ago, in his five thousand franc prize essay, that, with insufficient daylight, school rooms were best lighted by diffused electric light, the source being screened from the eye (2 and 4).

A negative answer to (5) would seem to follow if the first part of this letter is correct.

As an answer to (6) I would refer you to the article on Light, p. 584, vol. xiv. of the 1882 'Encyclopædia Britannica.' Among other things Prof. Tait says, "we cannot well define equality of illumination when the lights are of

different qualities." To be sure such measurements need to be made in practice, and a certain fixed artificial light standard, taken from daylight under agreed conditions, may be used. In any case the eye of the observer should be thoroughly examined and its condition known and stated with any observations publicly declared. No instrument can eliminate the need to consider the eye of the observer in measuring glare.

As regards (7) we are justified in saying that all experiments and observations for half a century have so far shown that the greatest damage to eyes results from ultra-violet rays, and that no material damage has been proved to be due to preponderance of any particular kind of light except the blue and violet. This does not mean that infra-red rays are necessarily good for the eyes, or that red light is entirely pleasant for all. Although it may not be practicable to obtain harmless light, it would seem to be theoretically possible to obtain light of the highest illuminating power which would not cause injury to the eye.

For street lighting I see no use in modifying the present lights in order to protect the eyes. Man has learnt to protect his eyes from the light of the sun, and as I believe distance and placing to be the most important practical factors for the protection of the eyes, the ordinary citizen should know better than to stare steadily at a light too near for his eyes. We cannot stay in the dark to protect our eyes, nor can illuminating engineers expect to find an artificial light which will be sufficient to illuminate objects properly forty feet away and do no harm shining directly into the eyes at two feet distance. For signal lights glare is even desirable, in order to attract attention.

I myself recommend glasses of amber yellow of a tint dark enough to cut off the blue yellow end of the spectrum for the prevention of the results of glare. I have been assured that amber yellow globes for artificial light are desirable from the decorator's point of view. These are indicated to preserve the illumination, and pink and green may be used when light is to be cut off. Ground glass globes diffuse the light, a very desirable thing with the incandescent filament, but they cut off 25 to 40 per cent of the illumination. The *Optical Review* of Philadelphia in 1903 remarked upon the coincidence of the finding of a German artillery surgeon that amber yellow shooting glasses improved the scores at the range $33\frac{1}{3}$ per cent, and mine that the same percentage showed improved vision by an indoor test. In the subsequent year the President of the Royal Opthalmalogical Society of the United Kingdom, in a discussion on night blindness, recommended the trial of golden yellow glasses as they were used in India for shooting during twilight, in order to improve vision.

Let me conclude by assuring your Society of my highest appreciation of its efforts.

Dr. E. O. Sisson, Denver, U.S.A.—In considering the effect of glare on the human eye, the writer's observations have been chiefly concerned with the effect of natural glare, viz., intense sunlight. While no visible lesion has been demonstrated, either macroscopically or microscopically, there is in these cases what the author would call a hypersensitiveness of the retina. It is probable that this hypersensitiveness is brought about largely by the action of the rays within the visible spectrum, although Steinmetz has demonstrated that the radiation of the sun contains ultra-violet rays, and a larger percentage, compared with the total radiation, than any glass-enclosed artificial illuminant. Whether the hyper-sensitiveness is produced by the rays within the visible spectrum or the ultra-violet rays, the facts remains that people coming to this part of the United States seek relief sooner or later from what they term as, "Light hurting the eyes." This applies to the entire great plateau region of the west and southwest.

Those who have small errors of refraction and have not found it necessary to have them corrected in the eastern part of our country, find, after a short residence here, that in order to have comfort for the eyes they must

put on glasses. This is the experience of my colleagues as well as myself. The fact that glass is more or less opaque to ultra-violet rays may be largely responsible for the relief gained.

These are simply clinical suggestions, and, in view of the difficulty of gathering statistics of a demonstrable nature, they will probably remain so. Still, they help to confirm an impression as to the existence of the deleterious effect of intense artificial illuminants and are valuable for that reason.

The effect of artificial illuminants is somewhat different, and this subject can be studied more intelligently, both by the physiologist and the engineer. Stockhausen's investigations show that the greatest amount of light the human eye can stand is a surface brightness of about 0·75 of a Hefner candle to the square centimetre, but he does not state whether this is the normal eye of a blonde or brunette. In a recent article on 'The Effect of Intense Sunlight on the Eye of the Blonde Type,'* by the writer, it was shown, as a result of a study of comparative anatomy, that the effect of illuminants is modified by the anatomical and histological structure of the eye. In view of this, one would naturally draw the deduction that the opening and closing of the pupil-aperture would not form a very reliable physiological test, by which it could be ascertained whether the existing illuminant was open to objection on account of glare as set forth in your list of queries. If such a test were used, an eye with a light-coloured fundus, *i.e.*, with little pigment, should be chosen as a standard, and the various pupillary phenomena that sometimes exist, such as hippus in its pathological sense, oscillation occurring synchronously with the heart-beat and respiratory movements, Wernicke's hemiopic pupillary reaction, Argyll Robertson pupil, anisocoria, orbicularis pupillary reaction, and paradoxical reactions must be sought for and eliminated.

Recent medical literature teems with reports of the injurious effect of ultra-violet rays on the eye and with methods for the prevention of such effects. Chief among the investigators along the latter line in this country is Dr. L. Webster Fox* of Philadelphia. At the last meeting of the American Medical Association he presented before the Ophthalmological Section an article on 'Amethyst Tinted Lenses,'* and recommended their use to prevent injurious effects from ultra-violet rays. The spectroscopic analysis of this amethyst glass showed that it cut out a certain proportion of the greenish-yellow light of the spectrum, 10 or 15 per cent.

That the ultra-violet rays are not alone responsible for ocular lesions caused by excessive light is shown by the effect of monochromatic light on the visual purple of the eye.

It has been demonstrated that the greenish-yellow rays emanating from artificial illumination, which is reflected into the eye from a material having a high degree of reflection, constituting glare, rapidly bleaches, or uses up, this protecting tissue of the retinal elements, and it can only be reproduced by exclusion of light. In the case of people following certain vocations, the eye is exposed for long intervals day after day to this reflected light, in which case the pigment is rapidly used up and does not have a chance for reproduction. The natural consequence is that the retinal elements are exposed to a constant source of irritation, which eventually results in ocular disease.

In view of the fact that many of the newer types of lenses suggested for protection from ultra-violet rays cuts out other rays emanating from the visible spectrum, their value may be attributed to such an action, rather than to the elimination of ultra-violet rays.

Dr. W. Voege (Hamburg).—As regards query No. 3, some recommendation on the lines stated seems desirable.

I believe that there are no particulars available of a method of measuring "glare" (Query No. 6), but I should be inclined to suggest the following method based on photography. One selects as the measure of the highest

* Sisson, Ophthalmology, January, 1909.—'An Inquiry Into the Effect of Intense Sunlight on the Eye of the Blonde Type.'

* Fox, Journal American Medical Association, July 10, 1909, Vol. LII., No. 2, p. 108, 'Amethyst Tinted Lenses.'

permissible intrinsic brilliancy some source of light, such as an incandescent gaslight surrounded by a matt diffusing cylinder, an open gas-flame, and so forth. Immediately behind this source we set up a white diffusely reflecting surface and obtain a photograph of the source superimposed over that of this illuminated surface. The relative blackness of the two images will then be compared. In order to reduce the intensity of the source, from a photographic standpoint, it may be serviceable to introduce a yellowish glass screen which cuts off the photographically active portion of the spectrum without too strongly absorbing the visible region ; this screen, however, does not cover the illuminated surface, but only the source.

The source to be tested is treated in exactly the same manner as the " unit " established as indicated above. The contrast between the darkness of the source itself and that of the illuminated surface should not exceed a certain maximum, namely, that occurring in the case of the " unit."

It may also be found more convenient to place the illuminated surface at some distance from the source and to form an image of the latter on it by means of a convex lens, the surface with the image focussed upon it, being photographed as described above. Which of these two methods is preferable must, of course, be decided by experimental tests.

As regards Query No. 7, it may be said that an illuminant ought theoretically to possess a spectrum resembling as closely as possible that of daylight. Continued exposure to monochromatic light, for example, would probably be injurious. Ultra-violet rays play only a subordinate part in comparison with visible light in causing dazzle, since they are unable to penetrate to the retina.

I may also add that many advertisement-lamps in the street are much too dazzling, and that the newest high pressure incandescent gas mantles require to be screened by some form of diffusing globe instead of clear glass.

Dr. H. Krüss, HAMBURG.—With reference to Query 6, I should like to point out that the measurement of glare must be decided by consideration of the definition. By " glare " we understand a quantity equal to $\frac{I}{S \cos \epsilon}$ (where I = the intensity of the luminous source, S the total area over which this intensity is distributed, and ϵ the angle of inclination of the surface to the eye : S cos ϵ is thus the apparent area).

In order to determine the " glare " or intrinsic brilliancy of an illuminant, therefore, two measurements are to be made :—

(1) We must measure the intensity of the source. This can be done in the ordinary way by the use of a suitable photometer.

(2) We must determine the apparent area of the surface when viewed at the prescribed angle. This can be conveniently done by means of the Krüss " flame-measurer." This consists essentially of a lens which forms an image of the luminous object upon squared paper ; the area of the image is readily calculated and thence the area of the actual source easily determined when its distance from the lens is known. This arrangement is specially intended for the measurement of intrinsic brilliancy and can be attached to the photometer utilised to measure the candle-power of the source investigated, both instruments receiving rays from the source in the prescribed direction.

Prof. H. Strache, VIENNA (*communicated*).—(1) " Glare " is due to excessive contrast of light and shade, especially when the surface illuminated is not extensive.

(3) Sources of light utilised to illuminate an interior should always be placed at such a height that the rays of light cannot enter the eye horizontally.

(4) Glare is not dependent on high illuminating power only, but, as suggested in (1), on contrast. When the eye is first directed on a dark surface, and subsequently turned towards one of greater brilliancy, the pupil is momentarily too wide open and the retina receives too much light. Excessive contrast is therefore physiologically undesirable because it implies continual readjustment of the eye. Flickering

and unsteady sources of light are open to objection for the same reason.

(5) The area of the pupil-aperture is controlled mainly by the average intensity of illumination ; it is, therefore, not a satisfactory means of judging whether the degree of contrast is too great.

(7) Ultra-violet rays are unquestionably more injurious than those of longer wave-length.

(8) The amount of light given by the arc lamp is not too high, and when lighted up in daylight does not appear glaring. Yet the contrast between the light itself and the dimly lighted street may be excessive, and the tendency towards unsteadiness is objectionable. It is desirable to devise some means of screening the eye effectually from the direct rays.

Herr Prenger, Director of the Gas and Electricity Works, Cologne.

Many of these queries, such as 1, 4, and 10 fall almost exclusively within the province of certain specialists ; for example, 1 and 4 should be answered by the oculist, and 10 by the architect.

As regards 2 I should like to point out that the habitual use of powerful arc-lamps outside shop-windows at a height of only two to three metres is very prejudicial to eyesight, but this drawback could frequently be modified by the use of suitable reflectors directing the rays into the window itself instead of the eyes of the passers by.

In many schools and drawing offices in Cologne the semi-inverted system of lighting with incandescent lamps has been found very serviceable In interiors it is certainly desirable that any powerful sources of light hung at a relatively low level should be effectively screened

Light—The Friend of Man.

An interesting instance of the symbolism of light, (a subject which has been very fully treated in the series of articles lately contributed to these columns by Dr. M. Gaster), is afforded by the play by Maurice Maeterlinck, 'The Blue Bird,' now being performed at the Haymarket Theatre.

The production of this play depends upon a number of exceptionally ingenious stage-effects many of them involving special lighting arrangements, and the colour-harmonies in the various scenes have attracted special interest. In addition the scheme of the plot and the various characters illustrate, in an interesting manner, popular ideas regarding light and darkness.

Thus in the third act the children who are the hero and heroine respectively of the play make their way into the Palace of Night, into which Light cannot enter. In this palace the children learn that most evil things have their dwelling, including ghosts, shades and terrors, sicknesses and wars.

The children are accompanied on their pilgrimage by fire, water, bread, the cat, the dog, sugar, light, &c. Most of these characters exhibit some peculiar absurdity, and all except Light and the Dog are really inimical to man. Fire is an active but unreliable creature in constant altercation with water ; the Dog, faithful but dull, wages perpetual warfare with the deceitful Cat. Light alone is above these petty disputes, being regarded as the constant and all-powerful friend of man, and earns the dislike of the other creatures who beneath their apparent willingness, resent their servitude to mankind. More than once the children are rescued by Light's opportune arrival.

Illuminating Engineering Society.

(Founded in London, 1909.)

THE names of the following new members of the Society have been duly approved by the Council, and were announced at the meeting of the Society held on January 11th, 1910, at the house of the Royal Society of Arts, London :—

VICE-PRESIDENTS.

V.P., C.M.	Lummer, Prof. O.	The University of Breslau, GERMANY.

MEMBERS OF COUNCIL.

M.C.	Sprott, E. M.	Managing Director of the Imperial Acetylene Light Co., 123, Victoria Street, LONDON, S.W.

MEMBERS.

Baugh, J. H. Agar	92, Hatton Garden, LONDON, E.C.
Beeton, H. R.	Chairman of the Brompton Electricity Co., Richmond Road, LONDON, S.W.
Beutell, A. W., *A.M.I.E.E.*	Electrical Engineer, 31, Mount Nod Road, Streatham, LONDON, S.W.
Clarke, J. B. *A.M.I.E.E.*	Electrical Engineer, to the Northampton Electric Light & Power Co., 73, Derngate, NORTHAMPTON.
Clark, H. N. *M.Inst.Gas.Engrs.*	Assistant Engineer to the West Ham Gas Co., Stratford, LONDON, E.
Findlay, J	Managing Director of the Rugby Lamp Co., Ltd., 92, Lower Hillmorton Road, RUGBY.
Fletcher, J. Y.	Electrical Engineer, 69, Queen Victoria Street, LONDON, E.C.
Giller, F. S.	Electrical Engineer, Assistant Chief of Maintenance Dept. Western Electrical Co., 174, Maxey Road, Plumstead, S.E.
Handcock, W. H. *M.I.E.E., A.M.Inst.C.E.*	Electrical Engineer, 1 Victoria Street, London, S.W.
Henrici, E. O., *A.M.I.E.E.*	Capt. Royal Engineers, War Office, London, S.W.
Hulse, H. R.	6, Holborn Viaduct, LONDON, E.C.
Kelly, R.	The Holophane Co., 50, Church Street, NEW YORK, U.S.A.
Kerr, Dr. James	Medical Officer, London County Council Education Offices, Victoria Embankment, W.C.
Kinzbrunner, Dr. C.	57–58, Chancery Lane, LONDON, E.C.
Mond, Dr. E. S. *F.C.S.*	Chemical Manufacturer, 22, Hyde Park Square, LONDON, W.
Pal, M.	Electrical Engineer, Parliament Mansion, Victoria Street, LONDON, S.W.
Ryves, R. A.	Supervisor of Public Works, Chepâk, MADRAS, India.
Seabrook, A. H., *M.I.E.E.*	General Manager, Borough of St. Marylebone Electric Supply Co., Springfield Road, LONDON, N.W.
Sheppard, E. G., *A.M.I.E.E.*	Works Manager, Robertson Electric Lamp Co., 72, Deodar Road, Putney, LONDON, S.W.
Wohlauer, A. A.	Consulting Electrical Engineer, and Lighting and Heating Expert, 546, Fifth Avenue, NEW YORK, U.S.A.

Among other applications for membership received since the last meeting of the Society may be mentioned those of Dr. W. M. Bayliss, M.A. D.Sc., F.R.S., Assistant Professor at University College, London, Dr. W. M. W. Ettles, M.D., F.R.C.S.E., &c., Pathologist to the Royal Eye Hospital, London, Prof. Grau, Vienna, Mr. S. Cowper Coles, &c.

The Illuminating Engineering Society.

(Founded in London, 1909.)

ANNIVERSARY DINNER, February 10th, 1910.

At the last Council Meeting it was decided to hold an **Anniversary Dinner** on **Thursday**, the **10th** of **February, 1910,** at 7.30 P.M., this being just a year since the formation of the Illuminating Engineering Society in this country.

In fixing this date the Council have been influenced by the general feeling that the Society would benefit by such an opportunity of bringing together those likely to be interested in its aims and objects, and it is anticipated that a number of distinguished guests will be present. The chair will be taken by the President, **Prof. S. P. Thompson, D.Sc., F.R.S.**

It is earnestly hoped that members will make a special effort to be present on this occasion, and that they will also endeavour to bring with them, as guests, several friends whose sympathy and support would be of value to the Society.

The dinner will be held at the **Criterion Restaurant, Piccadilly,** London, W., and the price of tickets will be **10s. 6d.** (exclusive of wine).

Will you kindly state, on the perforated form at the end of this number, the number of tickets you require, and, if possible, also names of any gentlemen whom you desire to invite, accompanying your reply by a remittance covering the price of the Tickets.

Replies should be addressed to the **Hon. Secretary, Mr. L. Gaster, 32, Victoria Street, London, S.W.,** preferably not later than January 27th.

NEXT MEETING OF THE SOCIETY,

February 15th, 1910.

The next meeting of the Society will be held at the House of the Royal Society of Arts (John Street, Adelphi, London) on TUESDAY, FEBRUARY 15TH, 1910, at 8 P.M., when the discussion on '**Glare, its Causes and Effects,**' opened by Dr. J. H. Parsons, F.R.C.S., at the last meeting of the Society on January 11th, will be resumed. The chair will be taken by **The President, Prof. S. P. Thompson, D.Sc., F.R.S.**

Kindly reply to the Hon. Secretary, by means of the perforated form at the end of this number, whether or no you will be able to be present.

For Application Form for tickets, &c., see end of magazine. ☞

The Design of Reflecting Surfaces.

(From the *Physikalische Zeitschrift*, April 15th, 1909.)

It is rather singular that while so much attention has been paid to the design of reflectors intended to distribute the light in a given direction, relatively little research has been devoted to the corresponding qualities of the surface which is illuminated. Polar curves of distribution of light of new reflectors are usually published showing how the light is cast in different directions. By suitable designs we can either distribute this light or focus it at a particular point, just as we may choose.

In the same way it will be seen on consideration that the intensity of an image projecting on any surface will probably vary when viewed from different directions. If a good white mat surface is utilized it is assumed that the light is uniformly distributed, and over a wide angle this is very often true. In the case of a photometer we always aim at securing a surface such that it complies perfectly with this condition—a surface, in fact, such that Lambert's law is rigidly true.

An interesting point in this connexion has recently been raised by a writer in the *Physikalische Zeitschrift* Lehmann, April 15, 1909), who discusses the quality of the screens, which are usually used for projection purposes, *e.g.*, for cinematographic exhibitions, &c. The author prefaces his remarks on this subject by a general discussion of some of the physiological principles underlying painting and the representation of nature by pictorial means. The exact province of art is a fascinating subject with which the illuminating engineer is only indirectly concerned; still there is so much in illumination which has to do with artistic principles that such questions have for him more than a trivial interest. An ideal photographic plate would, presumably, possess the exact characteristics of the human retina. It would respond to the various colours of the spectrum, according to exactly the same law as the eye, and would appreciate the relative brightness of each in exactly the same manner.

Yet even were this the case, a photographic plate would probably never do exactly what our eye does, because of the part played by the mind, and the influence of mental association in interpreting what we see. The artist, however, would, in general, contend that his art is creative, and that he is not merely concerned with the imitation of nature. To a certain extent photography partakes of art in that there is room for manipulation in the process of development according to the fancy of the operator.

Subjective impressions, however, are caused by physiological effects, and the author in the contribution referred to points out how the means at the disposal of both artist and photographer fall short of what is needed, in order to imitate exactly the impression received by our eye. For instance, the use of pigments must always be unsatisfactory because of the comparative restriction imposed by this method of producing light and shade. Even under the best conditions the illumination in a picture must often fall far short of that occurring in actual nature, and the *contrast* of light and shade is limited by the reflecting power of the pigment. Conceivably the art of the future may utilize some method of light-projection in which a greater degree of contrast in light and shade is possible.

It is therefore of some interest to consider what defects from this standpoint exist in the projection method. It is often difficult to secure the desirable degree of illumination even when this means is employed; for instance, in the case of the cinematograph, where a very small image must be projected on to the screen with a corresponding loss in the light available. For physiological reasons a great reduction in luminosity may not only effect the relative value of different colours, but

may also, as explained above, fail to reproduce the correct relative value of light and shade, simply because our eyes behave differently when subjected to different orders of illumination.

The author whose work has been referred to above has sought to secure a higher degree of illumination by modifying the kind of screen used. For ordinary purposes white paper or linen screens are frequently used. Such surfaces may, according to the results of Sumpner and others, possess a fairly high coefficient of reflection. They may, for instance, perhaps reflect as light 80–90 per cent of the rays of light falling upon them. At first sight, therefore, it would appear that no improvement in this direction was possible. But it must be remembered that much of the light reflected from such a white surface is not usefully employed, because it goes in a direction in which it does not reach the audience. Such a surface distributes its light almost uniformly. A polished metal reflecting surface would do exactly the opposite of a white paper, for in many directions no light would be reflected at all. What is really wanted is a screen which would concentrate all light thrown upon it in towards the audience, and yet still produce a perfectly continuous and effective image.

The author has therefore endeavoured to devise surfaces made by depositing metal so as to form a variety of reflecting surface which is intermediate in character between the two types described above. Such surfaces are preferably made, he says, by applying a material, such as aluminium powder, by the hand on an adhesive background. It is also suggested that by making suitable small projections of a given shape over the surface, the angle over which the light is reflected can be modified within a considerable range. It is even possible, he states, to produce a well-marked maximum in a desired direction, if need be, by suitable design of the facets.

Such screens are claimed to possess considerable advantages for projection purposes. They appear to have about the same order of coefficient of reflection as mat white paper, &c., and therefore would presumably reflect the same *total* amount of light from a given impinging flux, but concentrated within a certain angle, instead of thrown out in all directions. A very much brighter image, as seen perpendicular to the screen, can then be obtained, as will be seen from the adjoining table.

Surface.	Relative Maximum Brightness.	Effective Angle over which Light is Reflected.
1. White Paper	1·0	
2. Smooth Aluminium	13·8	48°
3. Shirting ,,	7·8	61°
4. Rippled ,,	3·4	84°
5. Alluminium deposited on Celluloid	3·4	71°
6. Aluminium powder deposited on adhesive surface	2·9	56°
7. Coarse Frosted Glass Silvered	1·6	96°

Of course a member of the audience looking at the screen from a very oblique angle would receive but little light, and would not see the image properly. It is urged, however, that this is of small importance, because in any case the perspective for such an observer would be so bad as to prevent him from seeing the picture well. For this reason it is now preferred to use long and narrow rooms for entertainments, so that all the audience look practically vertically towards the screen. In support of this contention the author gives a series of curves illustrating the manner in which the apparent illumination of an image would vary at different angles, as compared with that of the same image on white paper. These were obtained by direct observation with a Weber photometer. The general nature of the results, however, will be understood from the above table.

One consequence of the improvement in the brightness of an image so obtained is said to be that the blue and violet shades are very materially improved, these being the first colours to suffer through a weakening of illumination. These reflecting surfaces are also said to be specially adapted for use with the microscope since brightness is here very essential, and the range of view of the observer is practically restricted to a given direction.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Reduction in the Cost of Gas.

Recent Announcement of the Gas Light and Coke Co.

THE New Year brought a welcome gift to some half a million of London householders, in the shape of the announcement by the Gas Light and Coke Company of a further reduction in the price of gas. At the commencement of last year the Company rduced its price from 2*s.* 10*d.* to 2*s.* 9*d.* per 1,000 cubic feet, and now a further drop to 2*s.* 8*d.* is announced—making a total reduction of 4*d.* per 1,000 feet in the past five years.

Gas is widely used in the home, not only for lighting—in which field the economy and effectiveness of the inverted incandescent burner have proved of very great benefit to gaslighting—but also as a cleanly and convenient substitute for coal, and it is therefore anticipated that this gradual but steady decrease in price will be appreciated by a great many people.

It is naturally expected that this will lead to a still greater consumption of gas for fuel, both in the home and in the workshop and factory, and it is claimed that a large and growing volume of testimony from medical and scientific men yields support to the conviction that a properly designed gas fire, properly fixed and intelligently used, is not only not less, but is actually more hygienic than a coal fire (in which unpurified gas is burnt). The use of gas fires is extending this winter more rapidly than ever ; whilst the cleanliness, the saving of labour, the certainty and perfect control of heat ensured by the use of gas for fuel in industrial processes are leading to the rapid displacement of all labour-requiring, dirt, and ash-producing fuel by the heat which is instantly obtainable by the simple turning of a tap and applying a light.

The policy of reducing prices, and at the same time giving prompt and businesslike attention to every requirement of their consumers which the Gas Light and Coke Company has adopted of late years has already proved itself to be sound, and is destined to bear even greater fruit in the future.

Modern Gas Lighting.

THIS is an attractive pamphlet issued by the Boston Consolidated Gas Co. to which we hope to refer in greater detail on a subsequent occasion. Besides being attractively got up, this publication is interesting as an indication of the alertness of some gas companies in the United States to take advantage of the most recent progress in illumination.

We notice, for example, that reference is made to the work of Dr. H. E. Ives and his researches on the colour of artificial illuminants and also to the subject of intrinsic brilliancy. There are also sections on 'Residence Lighting,' 'Store Lighting,' and 'Commercial Lighting,' illustrated by photographs of installations and various recent designs in decorative fixtures.

Gas and Illuminating Engineering.

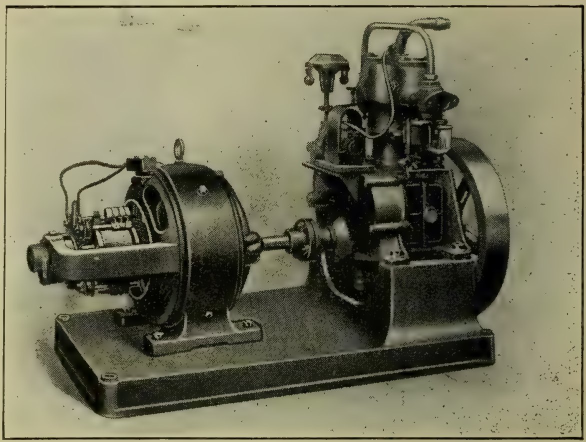
EVERY man who plays bridge has at least some good rules, and perhaps the more rules he has the better bridge player he is ; but when he knows how to break rules, then he begins to win games. In illuminating engineering it is the ability to know when to break rules that secures business.—*The Secretary of the Michigan Gas Association, Am. Gaslight Journal,* Nov. 1, 1909.

It would appear that if we would do our duty to-day we should in some measure at least be illuminating engineers. A definition of an illuminating engineer has been given as "a gas engineer with common sense."—*R. J. Thompson, Seventeenth Annual Convention of the Pacific Coast Gas Association.*

Electric Lighting and Power Sets, Working on Petrol or Paraffin.

FROM the **Union Electric Co.** (Park Street, Southwark, London, S.E.), we have received particulars of the Union Electric Lighting and Power Sets. These sets are intended to be especially suitable for Country Houses, Small Workshops, and Shop Lighting, where a supply of electricity is not readily available and where reliable and simple form of plant needing very little attention is essential.

The catalogue before us contains full specifications relating to the Engine and Dynamo, Switchboards and Batteries required for lighting of this description, either 25 or 50 volt circuits being provided for.



"Union" Lighting Set working on Paraffin. 1·25 K.W.

Tests on Tungsten Lamps.

WE have received from the **Westminster Testing Laboratory**, York Street, Westminster, London, a notice of a series of life-tests carried out on a number of different modern makes of metallic filament incandescent lamps. Tests of candle power were made at intervals of 200 hours throughout a period of 1,000 hours, the pressure being maintained constant within ½ per cent., by means of an automatic voltage-regulator.

The results of the tests have been printed in full, and bound up in one leather covered volume. In addition to giving the results for each lamp individually, they also give the average of all of each make at each period, and the average for each make throughout the whole run.

The subscription required to obtain a copy of the complete report is £2 2*s* Additional copies may be obtained (for personal use only, but not for resale), at £1 1*s*. each, by application to Mr. L. Wild, Chief Electrician of the Laboratory.

The "Zed" Fuse System.

Messrs. Siemens Bros., Ltd. (Tyssen Street, Dalston, London), send us particulars of the "Zed" type of improved Cartridge Fuses, which, it is claimed avoid many of the difficulties hitherto experienced with fuses of this variety. The catalogue before us gives full details of the construction of the fuse and its application on switch boards. Among the chief advantages claimed for "Zed" Fuses are :—

All live parts completely enclosed.

Every cartridge tested. Correct section and length of wire guaranteed.

Molten fuse-wire remains in cartridge.

Guage ring prevents insertion of cartridge of too great capacity.

Entire absence of "flash" or "arcing."

Can be replaced with safety on a "short circuit."

Replaced, even in the dark, in a few seconds without tools.

Immediate detection of blown fuse by means of Indicating Device.

Electric Flashing Signs for Shop Windows, &c.

ILLUMINATED signs continue to attract a considerable amount of interest, and we see evidence on every side of their extending use. The arrival of the bright illuminants of modern times was the signal

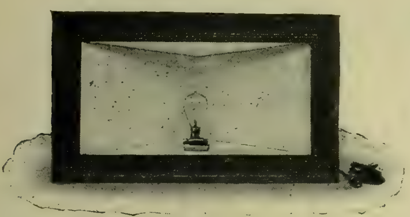


FIG. 1.

for the multiplication of such sources outside shops, the idea being that they attracted attention by their exceptional brilliancy. The installation of sources which are deliberately "glaring" to the eye is certainly unsatisfactory, and

FIG. 2.

possibly the tendency towards greater brightness in general illumination may in time bring its own remedy, since bright lights are now so common as to excite comparatively little comment.

A method which many people might prefer from the physiological and also from the practical standpoint is the use of transparent signs which can excite attention by their colour or quaint lettering, and need not possess an excessive brilliancy. Such signs are becoming increasingly popular, and some examples are shown in the accompanying illustration of type of the **Electrical and Engineering Supplies Co., Ltd.** (36, Upper Thames Street, London, E.C.). The source of light is here a single lamp backed by a matt white reflecting surface.

FIG. 3.

Another type of sign for shop lighting is that shown in Fig. 3 for the use of which we are indebted to **Messrs. W. Leonard & Co.** (4, Soho Street, Oxford Street, London, W.). The sign is usually made of hammered copper, the letters being cut out of the metal and an opal reflector fitted on the back, which is removable for feeding purposes. Such signs are intended to be placed in the shop window, and are claimed to have the advantages of not offending the eye by an undesirably high intrinsic brilliancy. In addition, the lights placed behind the sign may be arranged to throw the lights on the goods below.

Low Candle-Power Tantalum Lamps.

Messrs. Siemens Bros., Ltd., draw our attention to the fact that they are now placing on the market 10-c.-p. tantalum lamps for pressures of 50–60 volts for either direct or alternating current, and for direct current only, for pressures of 65 to 120 volts.

They are also placing on the market a direct current 16-c.-p. lamp for 140 to 160 volt circuits. The price of both lamps, for the above voltages, will be 2*s*.

Tantalum lamps are now made in voltages ranging from 20 to 240 volts for ordinary use. Tantalum candle lamps can also now be obtained in voltages from 20 to 60 in 5 or 10 c.-p. at the price of 2*s*. each. These candle lamps are specially intended for candelabra fittings.

The efficiency is 1·7 watts per British candle-power. It has also been decided to slightly alter the types of bulb, the diameter being rather less, but the length approximately the same.

CORRESPONDENCE.

The Calculation of Mean Spherical and Mean Hemispherical Candle-power from Polar Curves of Light-Distribution.

To the Editor of 'The Illuminating Engineer,' London.

DEAR SIR,—The writer has read with interest Mr. Bloch's articles in *The Illuminating Engineer*, and noted in the article in the October edition the description of the methods of calculating mean spherical and mean hemi-spherical candle-power from photometric curves.

In the writer's opinion there is a simpler method of calculating these quantities than any method described by Mr. Bloch. This method is a slight modification of the method given by Mr. Wolhauer and referred to by Mr. Bloch. It is as follows :—

Measure the horizontal components of the candle-power at the angles of 5, 15, 25, 35, 45, 55, 65, 75, and 85 degrees from the vertical, both in upper and lower hemisphere, and add 10 per cent ($9\frac{1}{2}$ per cent to be strictly accurate) to each candle-power value thus obtained. The result will give the flux of light in lumens through each 10° zone from 0° to 90°.

From these values the total flux through any number of 10° zones can readily be found by addition ; the sum of all these values giving the spherical flux, the sum of those below the horizontal giving the lower hemispherical flux, and the sum of those above the horizontal giving the upper hemispherical flux.

If mean candle-power values are desired for each zone or sum of zones instead of flux values in lumens, we have simply to divide the lumens in the zone or sum of zones by the flux factor, which in the case of a sphere is 4π, and in the case of a hemisphere 2π.

The measurement of the horizontal components of the candle-power can most easily be made by means of a card or sheet of paper on the edge of which is marked off a scale corresponding to the candle power divisions of the diagram used. Such a scale is the work of a moment, and occasions but little trouble even if it has to be made every time a set of measurements is taken. If, however, most of the photometric curves to be investigated are made on diagrams having candle-power divisions of the same size, the same scale may be used for all of them. In such case the process is to measure the horizontal components of the candle-power in scale divisions, multiply by the candle-power corresponding to a division, and add 10 per cent to get the flux values.

Very nearly this same method of calculating flux was discussed in some detail by the writer and Mr. T. W. Rolph in the May, 1909, edition of *The Illuminating Engineer* (New York), but the method described in this article seems to the writer to be even simpler.

Yours very truly,

J. S. CODMAN.

93, Broad Street, Boston, Mass., U.S.A.

DEAR SIR,—The method specified by Mr. Codman in the above communication is similar to that proposed by Wohlauer (referred to in my article on pp. 685–86 in *The Illuminating Engineer* for October, 1909), and does not seem to me to lead to any simplification of the process. According to Mr. Codman's system the individual factors to be summed are individually multiplied by the factor 1·1, and the sum of these products subsequently divided by 2π or 4π in order to obtain the mean hemispherical or mean spherical candle-power, respectively. According to the Wohlauer process, on the other hand,

the sum of the terms is itself multiplied by the product of the two factors referred to, which is naturally more convenient. I consider the method described by me on p. 468 (*loc. cit.*), and illustrated in Fig 2 in the same article, simpler because it does not require any squared paper, but merely the setting up of the polar curve and the drawing of a circle of 10 cms. radius. Moreover the choice of 10 or 20 divisions is to be recommended since it is then only necessary to multiply the sum by one-tenth or one-twentieth respectively, an operation which can easily be carried out in one's head. I am, &c.,

DR. B. BLOCH
(Berlin).

The Lummer Brodhun Photometer.

DEAR SIR, — The correspondence between Mr. A. P. Trotter and Prof. O. Lummer on the subject of the Lummer-Brodhun photometer (*Illum. Eng.*, Lond. No. Jan. 1910, p. 67) leads me to add a few remarks on an instrument of this pattern manufactured by me (see *Jour. f. Gasbeleuchtung*, 1894, p. 61, 1896, p. 265). This is provided with glass plates which effectually keep out the dust and some hundreds have been sent out and have invariably given evidence of that high degree of accuracy characteristic of the Lummer-Brodhun arrangement.

Although, as stated above, the apparatus is, to all intents and purposes, dust-proof, that is not to say that a deposit may not gradually form on the glass surfaces inside the photometer, and such deposits are indeed inevitable when the instrument is used constantly in the laboratory of a gasworks. As long as these deposits are not very heavy they cause the observer no trouble. They may cause the instrument to be slightly unsymmetrical in its readings, but this is easily corrected by reversing the instrument through 180 degrees.

As a rule the observer can himself clean off such deposits after removing the cover. When, however, the deposit occurs on the hypotenuse-face of the prisms they can only be effectually cleaned by separating the two prism-faces. This is a delicate operation requiring considerable experience and dexterity and in such cases the instrument should be returned to the works. In this respect the instrument resembles many telescopes and binoculars, in which such prismatic arrangements occur, and the fact that it is occasionally necessary to return such apparatus for cleaning is not considered a very serious objection.

Mr. Trotter explains his not using the Lummer-Brodhun instrument on the ground that his particular researches were mainly concerned with the measurement of illumination, and the reflecting qualities of various surfaces, &c. It is, however, worth noting that measurements of this kind can also be made by the aid of the Lummer-Brodhun prismatic arrangement. For example the device was fitted into the Weber illumination-photometer, and in my arrangement for the measurement of surface-brightness (*Jour. f. Gasbeleuchtung*, 1902, p. 738 ; *Gas World*, 1892, p. 1106). I notice that Mr. Trotter does not mention this instrument nor that subsequently described by me for a similar purpose (*Jour. f. Gasbeleuchtung*, 1904, p. 917). Both these pieces of apparatus are, like the Trotter "Illumination - Photometer," serviceable for the measurement of intensity of illumination, and in my description of the latter apparatus I specially mentioned the portions of the Trotter instrument which I have utilized in my pattern ; it would be gratifying to me if Mr. Trotter would make a similar reference to my design.

This instrument makes use of the device for altering the intensity of illumination of the illuminated surface which has been described by Mr. Trotter in *The Illuminating Engineer* for 1909

on p. 800, *i.e.*, the characteristic piece attached to the horizontal spindle on which the test surface rests, and which enables an approximately uniform scale to be obtained as the inclination of this surface is adjusted. The shape of this support was exactly calculated by me in order to obtain the desired result. If Messrs. Everett, Edgcumbe & Co., have likewise calculated out the best shape they would naturally arrive at the same result, but it would be perhaps more satisfactory were a reference made to the similarity between the two instruments.

I, of course, take it for granted that Mr. Trotter has not previously had an opportunity of hearing of my apparatus.—Believe me, Yours, &c.,

Dr. H. Kruss (Hamburg).

The New President of the Illuminating Engineering Society in the United States.

We understand that at the last meeting of the New York section of the Illuminating Engineering Society in the United States Dr. E. P. Hyde entered upon his duties as the new President of the Society.

Dr. E. P. Hyde will be well known to our readers as one who has done much good work in connection with illumination and photometry. He is now in charge of the laboratory of the National Electric Light Association in the United States (the work of which he summarized in an interesting communication at the Third Annual Convention of the Illuminating Engineering Society (U.S.A.) last year (*Illum. Eng.*, Lond., Nov. 1909).

Dr. Hyde is also one of the corresponding members of our own society, and participates in the discussion on "Glare, its Causes and Effects," published in this number. We feel sure that our readers will join us in congratulating the new President and wishing him every success in his new office.

It is also interesting to observe that Mr. V. R. Lansingh, one of the Vice-Presidents and Corresponding Members of our Society, has been elected a Vice-President of the Society in the United States, while Mr. P. S. Millar is again General Secretary.

Some Publications Received during the past Month.*

The Practical Electricians' Pocket Book and Diary, 1910 (S. Rentell & Co. Ltd., 36, Maiden Lane, London, W.C. 1*s*. net).

Spons' Architects' and Builders' Pocket Price Book, 1910 (E. and F. N. Spon, Ltd., 57, Haymarket, London, W., 3*s*. net).

On the Necessity for the Use of Colour-Names in a Test of Colour Blindness, by F. W. Edridge Green, M.D., F.R.C.S., (Reprinted from *Treatment*, Vol. IX., No. 11, Jan. 1906).

We have also to acknowledge among others the following:—*American Chemical Journal, Proceedings of the Am. Institute of Electrical Engineers, Atti della Associazone Elettrotechnica Italiana, Journal of the Franklin Institute, Journal of the Royal Society of Arts, Transactions of the Illuminating Engineering Society (United States), Journal of the Society of Architects, &c.*

* To some of these publications we hope to refer in greater detail shortly.

Review of the Technical Press.

ILLUMINATION.

UNDER this heading we may refer specially to the *Transactions* of the Illuminating Engineering Society in the United States for October and November. These contain, *in extenso*, the interesting series of papers presented at the Third Annual Convention of the Society last year, which have previously been referred to in abstract in these columns.

A number of journals give editorial notice to the subject of illuminating engineering. Special mention should here be made of *Il Gaz* for December, 1909, which contains a lengthy summary of the constitution of the Illuminating Engineering Society in this country. The American *Illuminating Engineer* also refers to the inaugural meeting of the Society, and gives some extracts from the British technical press bearing on the subject. *The Journal of Gas Lighting* devotes an editorial to the last meeting of the Society, when the subject of 'GLARE' was discussed, and a number of other journals comment on the same matter.

Several papers and articles deal with STREET LIGHTING. Thus **H. Thurston Owens** discusses different types of lanterns and lamp posts in New York, and **Wrightington** describes the experiments on gas lighting in Boston, U.S.A., giving interesting particulars of the different types of incandescent gas lamps used. **J. Sumec** considers the question of the BEST HEIGHT FOR STREET LAMPS. In doing so he also discusses the different systems of measuring street illumination (*i.e.*, whether in a vertical or horizontal plane, or on the basis of mean or minimum illumination, &c.). He prefers to judge the effect by the product of the mean and the minimum illumination between two lamp-posts. In conclusion he suggests that the present often adopted height of 3·5 or 4 metres is too low; 5·6 metres is better, but 10 metres is better still.

An article by **J. W. Conelly,** in the American *Illuminating Engineer* is of interest in connexion with street lighting. The author points out the effect of good show window and STREET ILLUMINATION IN ATTRACTING TRAFFIC AND CUSTOM, basing his suggestion on data collected as to the number of people and vehicles passing down certain streets.

As regards shop lighting, it may be noted that many journals have referred to the recent accidents in some electrically lighted shop windows. These mishaps are attributed partly to bad workmanship, but also to the unfortunate system sometimes adopted of placing the lamps in the window among, and quite close to inflammable goods.

Among other articles we may note the study of the COLOUR EFFECTS OF DIFFERENT ILLUMINANTS, and their comparison with daylight, contributed by **H. E. Ives** in a recent Bulletin of the *Bureau of Standards* (U.S.A.)

J. S. Dow (*Illuminating Engineer*, N.Y., January), deals with FACTORY LIGHTING. The need of good illumination, both from the commercial and the hygienic aspect, is emphasized, and some particulars are given of the legislation in different countries on this subject. Special stress is laid on the value of measurements of illumination as a record of the condition of lighting in an interior.

PHOTOMETRY.

The Electrical World (Jan. 6) has an interesting GENERAL REVIEW of recent progress in this subject, special emphasis being placed on the agreement as to an INTERNATIONAL UNIT OF LIGHT. This point also receives attention once more in the *Journal für Gasbeleuchtung* (*J.f.G.*, Jan. 15), a letter from the Director of the Bureau of Standards being reproduced and critically examined. In defence of the new unit it is pointed out that the real custodian of the unit is the mean value of a series of standard glow-lamps, and it is urged that this enables it to be maintained to within one-fifth per cent. The question of national standards of light therefore does not enter in. The real German objection, however, seems merely based on the use of the word "international."

A note in *The Journal of Gas Lighting* (Dec. 29, 1909) refers to a patent of **H Chapman** on A RADIOMETRIC PHOTOMETER. This appears to depend on the radiometer principle, and is only intended for the comparison of lights of the same spectral composition.

B. Monasch (*E.T.Z.*, Dec. 30, 1909) criticizes the types of PORTABLE "PHOTO-

METERS " FOR GLOW-LAMPS based solely on the measurement of power or current. Such instruments may serve as a rough indication of the difference in efficiency of carbon and metallic filament lamps, but are very unreliable for the comparison of different types of metallic filament lamps with one another.

R. Stigler (*J.f.G.*, Jan. 15., abstract) points out the physiological conception of the brightness of two illuminated surfaces depends on the part of the retina on which the images of these surfaces are received. He also advocates binocular vision. The author is also stated in this abstract to have devised a system of measurement on which, however, nothing is here said.

ELECTRIC LIGHTING.

As usual a number of articles deal with the properties of metallic filament lamps, For example, **F H. Lavender** describes a series of tests on different types (*Electrical Review*, Dec. 31, 1909). **L. Crouch** and **C. Cheneveau** describe experiments on the connexion between the TEMPERATURE OF INCANDESCENCE and the behaviour of different metallic filaments. In both cases lists of the estimated temperatures are given, but it is pointed out that there is considerable uncertainty of the determination of these high temperatures. The relation between light and temperature, and the characteristic curves connecting watts, volts, temperature, &c., are worked out. Other articles deal with the manufacture of metallic filaments. *Electrical Engineering* (Jan. 6) refers to the B.T.H. claim of the master patent on the drawing of filaments from ductile tungsten alloys.

The MAZDA tungsten lamp is a new type of high candle-power, consuming about 250 watts (*Electrical World*, N.Y., Jan. 18). It is anticipated that this lamp will tend to replace small arc lamps consuming about 350 watts, and stated to yield about 1200 " nominal " candle-power.

There are also articles by **Wedding** and others on new types of flame arcs and **Hrabowski** (*E.T.Z.*, Jan. 6) describes an interesting new form of reflector, which is partly metallic and partly prismatic, for use with these lamps. It is said to improve the distribution of light for street illumination and to reduce the tendency to glare.

Among other articles of a general nature we note in a recent number of *Electrical Engineering* the interesting description of some electrical effects at Drury Lane Theatre, and a description of the new theatre in New York (*Electrical World*, N.Y., Jan. 6).

A. D. Rockwell (*Elec. Rev.*, N.Y., Jan. 8) refers to the value of light in medicine. Rays of short wave-length are useful for treating skin effects, but have little penetrating power. Visible rays, however, are useful in inducing perspiration, &c.

Lastly we may mention a note of the use of the mercury vapour lamp for sterilizing liquids (*Revue Électrique*, Nov. 30, 1909). It is suggested that the rays from this lamp produce oxygenization, and that this has a sterilizing effect on liquids such as milk, cider, &c.

GAS, OIL, ACETYLENE, LIGHTING, &c.

The new year numbers of the gas journals contain interesting summaries of developments during 1909. Special reference may be made to the Retrospect in *The Journal of Gas Lighting* (Dec. 28, 1909.)

Among recent papers read at technical societies, &c., we note that of **Fletcher** on INCANDESCENT GAS LIGHTING (*J.G.L.*, Jan. 11; *G.W.*, Jan. 15). The author describes a number of different types of burners, and discusses their advantages and drawbacks. He suggests that the plan of heating the air before it actually arrives at the outlet of an inverted burner is on the whole not beneficial, and states that the deterioration in the illuminating power of incandescent gas lamps is usually due to want of care for the burner rather than failure in the mantle. Some mantles, of a poor class, however, shrink away from the flame after a few hours burning.

A lecture of **Prof. V. Lewes** is reproduced dealing with the well-known ACETYLENE THEORY OF LUMINOSITY, according to which the luminous appearance of a hydro-carbon flame is to be ascribed to the formation and decomposition of acetylene therein. Reference is also made to the tests of Lux on the requisite amount of CERIUM IN MANTLES, which were alluded to in a previous review.

Among articles of a general nature we note that of Lansingh and Rolph, dealing generally with gas lighting. Apart from its intrinsic merits, the paper is interesting as having been read at a joint meeting of the Illuminating Engineering Society and the National Commercial Gas Association in the United States. The paper deals with a number of problems in lighting in a readable and lucid manner, and figures are given for the intensity of illumination required for the different conditions. The authors seem to suggest that there is at present no recognized system of desk lighting which can be considered entirely satisfactory.

A paper by C. N. Stannard, reported in *The Am. Gas Light Journal,* is also of exceptional interest. The author discusses the conditions enjoyed by a lighting company which controls both gas and electricity, and considers how the different fields should be allocated between the two systems. He arrives at the conclusion that heating should be surrendered exclusively to gas while electricity should be encouraged for the lighting of all but the poorer class of premises.

The *Zeitschrift für Beleuchtungswesen* contains a note of an interesting small type of burner which is claimed to have a smaller consumption than any other in existence. The lamp consumes 19 litres (0·67 cubic feet) per hour, and is stated to give 16 candle-power.

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CONTRACTIONS USED.

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G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

"The Illuminating Engineering Co., Ltd."—A Somewhat Fanciful Title!

We have received a notice of a recently formed company styling itself "The Illuminating Engineering Co., Ltd.," which was registered on Jan. 10th, with a capital of £10,000 in £1 shares. The business of the company is stated to be the acquiring of patent rights in an invention for improvements in apparatus for lighting and extinguishing gas. The first directors are G. R. Gill, J. S. Pollock, and C. E. Harrison.

We need hardly say that this company has no connexion whatever with The Illuminating Engineering Publishing Co., nor with the Illuminating Engineering Society. The title hardly seems to describe in an adequate manner the business of the company, for the sale of apparatus for lighting and extinguishing gas can only be considered a remote and subsidiary branch of the wide field of illuminating engineering. As has frequently been stated in these columns and has been pointed out by the Illuminating Engineering Society, the indiscriminate use of the terms "illuminating engineering" and "illuminating engineer" is very undesirable at the present stage, and there are at present few in this country in a position to term themselves illuminating engineers. As far as we know none of the directors of this company have taken any part in connexion with the illuminating engineering movement, and it will be interesting to watch how far their scheme of operations is in agreement with the name they have seen fit to adopt.

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

THE FIRST ANNIVERSARY DINNER OF

The Illuminating Engineering Society.

(Founded in London, 1909.)

On Thursday, February 10th, the first anniversary dinner of "The Illuminating Engineering Society" was held at the Criterion Restaurant, London, W.

It is interesting to recall that just a year ago a dinner was held at the same restaurant for the purpose of embarking upon the formation of this Society. At the conclusion of this dinner about 30 members were enrolled —a number that has now been increased to over 20

But perhaps it was even more gratifying to observe the representative character of the gathering at this last dinner, and the evidence of influential sympathy and support afforded by the speeches of those who were present.

The Illuminating Engineering Society, as a young body, has every reason to be grateful for the sympathy of older organizations. To receive the influential support of representatives of so many of the older distinguished societies was a most satisfactory confirmation of the value of our aims and the work so far accomplished.

Yet such support is in a sense only the natural consequence of the programme of The Illuminating Engineering Society. For, as its supporters have pointed out from the very commencement of the movement, the ideals of illuminating engineering can be summed up in the word "co-operation." No single individual, no society even, can pretend to have a monopoly of knowledge; we must rely upon the good-will and co-operation of those who have made a special study of certain fields of knowledge.

For details of the speeches of the various distinguished representatives of the many Societies who took part,

we must refer our readers to the account of this dinner on p. 193. We need only take this opportunity of repeating the welcome of the Society extended to them on that occasion and our appreciation of their sympathetic attitude. A special acknowledgment is, however, due to Sir Henry Trueman Wood who very kindly consented to take the chair at such short notice.

A gratifying and interesting item in the proceedings was the reading of the letters received from Sir Joseph Swan, Sir Wm. Preece, and Prof. A. G. Vernon Harcourt, consenting to act as the first honorary members of the Society. The presence of Prof. Vernon Harcourt on this occasion was very highly appreciated.

Glare, its Causes and Effects.

ON page 169 of the present number, readers will find an account of the discussion on the above subject at the last meeting of the Society on February 15th. On this occasion, the more familiar and practical aspects of the subject were dealt with, and the meeting was of a very interesting and representative character (though we may say, in passing, that we should like to have seen more representatives of the gas industry present, to participate in this discussion).

It was freely admitted that practically all the sources of the present day, when placed so that their rays fall direct on the eye, cause a painful and prejudicial effect. This possibility we must therefore avoid. We may do soby introducing a diffusing globe or screen cutting down the intrinsic brilliancy to the desired value, or in some cases by so placing the source a considerable distance away that the eye will never, or, at least, rarely, be able to receive the direct rays. In addition it is necessary to make special provision to prevent the possibility of reflected light from shiny surfaces coming into the eye, and so interfering with vision.

As regards the maximum permissible intrinsic brilliancy of sources which are liable to be exposed to the eye, there is some difference in opinion, but, on the whole, surprisingly good agreement. The figure suggested by Dr. Stockhausen is about 4·5 candle power per square inch. That advocated by Prof. L. Weber and Dr. Louis Bell about $2\frac{1}{2}$ candle power per square inch, while Mr. A. P. Trotter also thinks that a value in this neighbourhood would be satisfactory. On the other hand it may be recalled that a few workers, like Mr. J. E. Woodwell, have considered even lower figures desirable, and the last named, at the Second Convention of the American Illuminating Engineering Society in 1908, thought that 0·2 candle power per square inch was not too low a limit.

This general recognition of the nature and causes of "Glare," and of the need for special precautions to avoid it, is in itself evidence of a welcome change of view during the last few years. There still remain many questions of detail which are not completely understood and require further study, but we believe that meanwhile this collection of opinions on the subject of "Glare" will have a very influential effect in drawing the attention of the public to the matter, and will stimulate the desire for more scientific methods of illumination.

In passing it is interesting to note that Mr. W. M. Mordey referred in the course of his remarks to the illumination of the new home of the Institution of Electrical Engineers and stated that the council were bearing in mind the desirability of avoiding anything in the nature of glare. We are very glad to have his assurance that this is the case and hope to learn shortly exactly what steps are being taken in this direction. The system of lighting to be adopted in the new home of the Institution has been the subject of much speculation and we have several times had enquiries addressed to us on the sub-

ject. It is certainly to be desired that the best advice should be received in order that the Illumination may be worthy of its surroundings.

The discussions on the subject of "Glare" at the meetings of the Society terminated on February 15th. It was resolved, however, to appoint an International Committee to consider the subject further. Meantime we should like to mention that our columns are open to any of our contributors who would like to comment therein on the communications so far published.

A Central Authority to Deal with Public Lighting.

We observe that Mr. Corbet Woodall, at a recent meeting of the Gas Light & Coke Company, referred to the need for some central body to deal with the vexed question of public lighting. He mentioned several cases in which the decisions of local authorities on this subject had given rise to dissatisfaction, and remarked that this is a matter which calls for prompt and searching investigation. He proceeded to suggest that a suitable Commission should be appointed either by the Treasury, or the Local Government Board or the Board of Trade — neither of which bodies, he added, appears to possess adequate power to deal with the matter at present.

This is a suggestion which has been put forward in these columns on several occasions in the past, and we are glad to see that the need for such an advisory authority is becoming increasingly recognized. We have always pointed out (see *The Illuminating Engineer*, Lond., 1908, Vol. I., page 532, Vol. II., 1909, page 579) that the illumination of streets and public buildings is a matter which deserves scientific treatment on its own merits and that it should be kept as far as possible independent from outside considerations.

There is a great need for some central authority whose decision would carry the necessary weight. But to be of any value, as we pointed out in one of the notes mentioned above, "The impartial and technical standard of such body must be beyond question, and the commercial interests must be well balanced."

We have also pointed out that such a central authority need not necessarily possess the power to interfere unwarrantably in local decisions. It would, however, serve as an authority to whom appeal could be made in case of dispute. It would also undertake a special study of public lighting, and be prepared to supply information and advice when they were needed. We, therefore, hope that the necessary steps will be taken in the direction which Mr. Corbet Woodall suggests, and that we may see—what both electrical and gas representatives, we feel confident, now desire—some attempt to lift the subject from the level of embittered controversy to temperate and scientific discussion.

Indeed, so important, from the standpoint of public health and convenience, are all the various aspects of illumination now felt to be, that the appointment of a Royal Commission, to deal with the matter on a broader basis, might even be suggested.

The Gas Industry and Illuminating Engineering.

In several of our previous numbers we expressed our desire to see the gas industry taking a greater interest in the illuminating engineering movement, and we confidently believe that our expectations and desires in this direction will be fulfilled. We have already seen in the United States how many gas experts are now taking a keen interest in the proceedings of the Illuminating Engineering Society in that country.

We may also refer to the criticism which was recently levelled against our American contemporary, *The Illuminating Engineer* of New York (and to which that journal has since replied in very judicious terms), to

the effect that it did not devote sufficient space to gas. We think that those who make this criticism forget that gas lighting, in spite of its vitality and recent progress, is after all now a thoroughly established and permanent system which has met with and overcome most of its difficulties, while electricity is still in the process of development. Naturally, therefore, we must expect that for a time there may be more researches on electric lighting to record. A study of the gas journals of the present time supports this supposition. Even here we find that, as a rule, only a comparatively small space is devoted to information on really novel and scientific developments in connection with lighting. Naturally, therefore, a journal which seeks to deal with all illuminants cannot be expected to do more—bearing in mind the limited space available. After all, it must be remembered that problems in illumination which are common to *all* methods of lighting in themselves often form an extensive field for study.

But in any case it is evident that the matter rests very largely with the gas engineers themselves. Our contemporary in New York, like ourselves, is, we feel sure, only too willing to deal with particulars of the latest developments, but, with a few gifted exceptions, it is not very easy to find contributors who have at once the requisite knowledge of the subject, and the leisure to write. In other words, the really able man in this field is unfortunately often too fully occupied with business to undertake literary work. We can only reiterate our desire to do full justice to any information of scientific value that is forthcoming on the subject and renew our invitation to authorities to keep us fully informed.

The Measurement of Light and Illumination.

The next two meetings of the Illuminating Engineering Society are to be devoted to a discussion on recent developments in the measurement of light and illumination. On page 168 will be found a list of queries which have been prepared in order to suggest a few matters which might profitably be dealt with in these discussions. It should, of course, be understood that the list is not intended to be in any way exhaustive.

It will be observed the ground covered by these enquiries is again very extensive, and it may be found impossible to answer them fully in the time at our disposal. Should this be found to be the case, however, we need not be greatly concerned; the mere issue of such suggestions will help to stimulate enquiry and to illustrate how much there is yet to be known on these subjects. We may, therefore, hope that they will be beneficial, and that many things on which we are not able to speak definitely at present, will become clearer in the future.

It has also been found desirable to allow two evenings for these discussions and, as in the case of the discussions on "Glare," to aim at the treatment of the more direct *applications* on the second evening. We hope that the subject will give rise to an interesting discussion, and that it will help to suggest lines of profitable research.

The question of the measurement of Light and Illumination like that with which the Society has been dealing, goes to the very root of successful illuminating engineering, and we trust that we shall, as before, receive an exhaustive series of contributions in writing from those who are unable to be present on this occasion. LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 151) now considers the direction which the test plane in a photometer should face, when measurements are being carried out in the streets; he also discusses the relative advantages of MEASUREMENT IN HORIZONTAL PLANES, IN THE VERTICAL, OR AT 45 DEGREES. He also says a few words regarding the value of coloured screens in photometry, referring particularly to the use of the PRINCIPLES OF "CROVA." In this method screens, dyed a yellow colour, are employed and intended to secure approximately the same coloured light on both photometric surfaces; allowance being made for the light absorbed by the coloured surfaces.

Dr. W. Coblentz (p. 155) having concluded the portion of his article dealing with the "grey body," now proceeds to the discussion of the SPECTRA OF INCANDESCENT METALS AND NON-METALS, OXIDES, &c.; he gives illustrations of the radiation curves obtained from the metal osmium and the oxides used in incandescent mantles.

The above article is followed by two of a shorter nature. The first deals with an interesting suggestion of the ILLUMINATION OF THE WHOLE OF LONDON by a single source, in the eighteenth century. An illustration is given of the suggested arrangements which involve the use of a powerful lamp and chimney surrounded by a series of parabolic glass reflectors.

On p. 162 will be found particulars of a modification in the SYSTEM OF LIGHTING AT THE PATENT OFFICE (LONDON). This consists in the addition of table lamps for the benefit of readers which are provided with Holophane reflectors terminating in cardboard shades at the base so as to concentrate the light on the tables, but to completely screen the eyes of the readers. Following this will be found a short account of the recent lecture by **Mr. A. Angold** dealing with DEVELOPMENTS IN MODERN ARC LAMPS.

A full account is given of the discussion at the last meeting of **The Illuminating Engineering Society** of Feb. 15th on the subject of "GLARE AND ITS CAUSES AND EFFECTS" (p. 168). On this occasion the discussion was opened by **Mr. A. P. Trotter,** who described an instrument for measuring the contraction of the pupil when exposed to an illuminant. Mr. Trotter also discussed the question of the permissible intrinsic brilliancy of sources, and thought that the surface-brightness of a candle, viz., about 2·5 candle-power per square inch, might be regarded as a reasonable limit.

Mr. J. H. A. Baugh showed some experiments illustrating the effects of different kinds of globes and their effect in causing glare.

Mr. W. R. Cooper thought that glare was generally a matter of contrast, and referred to the necessity of studying the question imposed by the principles of the metallic filament lamps. He also referred to several examples of illumination of buildings in which glare was very noticeable.

Mr. W. M. Mordey referred to the unpleasant effect of bright lamps placed against dark backgrounds and said that in the illumination of the new building of the Institution of Electrical Engineers special precautions should be taken to avoid glare.

Mr. Haydn T. Harrison also emphasized the painful effect of excessive contrast, and referred to the possibility of reducing glare in street lighting by the use of suitable reflectors.

Mr. L. Gaster mentioned a number of instances such as schools, libraries, &c., in which it was very desirable to avoid glare. Finally he read out a resolution suggesting that an international committee should be formed to clear up points which were still in dispute.

In closing the discussion **The President, Professor S. P. Thompson,** D.Sc., F.R.S., referred to the number of different factors, in connection with the behaviour of the lens of the eye and the retina, which affected the sensation of glare, and said that he believed the international commission suggested might be very beneficial.

Some further communications from foreign members will be found on p. 178. The exhaustive discussion by **Dr. K. Stockhausen** (Dresden) is continued. In the present section he gives fuller details of the effect of ultra-violet light on eyesight, and he also discusses the best method of measuring intrinsic brilliancy. A distinction he says should be drawn between horizontal and spherical values. Turning to practical applications, he criticises the existing methods of street and shop lighting and advocates that an International Commission should be appointed to collect information on the subject of Glare and to reconcile the views of different authorities.

Dr. H. Lux (Berlin) (p. 184) also deals with the measurement of intrinsic brilliancy, and describes a piece of apparatus which, he suggests, enables this quantity to be determined with much greater exactitude than the methods hitherto proposed.

Professor A. Grau (Vienna) emphasizes the parts played by intrinsic brilliancy and excessive contrast, in causing glare, but thinks that the ultra-violet rays contribute but slightly to this effect (p. 186.)

A communication from **Messrs. Korting & Mathieson** (Berlin) will be found on p. 187 in which the question of glare is discussed in much detail and the practical possibilities in the way of avoiding it in different types of interiors are considered. The method of inverted lighting with arc lamps is recommended, but in some cases, nevertheless, direct or semi-indirect systems are desirable.

On p. 168 will be found a series of queries on the subject of Recent Developments in the Measurement of Light and Illumination, which is to form the subject of the discussion at the next meeting of the Illuminating Engineering Society on March 15th.

Following this notice will be found an account of the First Anniversary Dinner of the Illuminating Engineering Society, which was held at the Criterion Restaurant, London, W., on February 10th, 1910 (p. 193). In the absence of the President the chair was taken by **Sir Henry Trueman Wood**, and distinguished representatives of the Institution of Gas and Electrical Engineers, the Royal Sanitary Institute, the Physiological Society, the Home Office, the Electrical Contractors' Association, &c., were present. A full account is given of the various toasts proposed on this occasion, and the speeches expressing appreciation of the aims and objects of the Illuminating Engineering Society. Sympathy was expressed with the desire of the Society to secure full co-operation on behalf of older bodies. A special item of interest was the announcement that **Sir William Preece, Sir Joseph Swan,** and **Professor A. G. Vernon Harcourt** had consented to become the first **Honorary Members** of the Society,

Among other articles we may mention that of **Mons. A. Guiselin** (p.203), who describes some experiments on the value of different kinds of Petroleum for Illuminating Purposes. He finds that the relative vaule of different kinds of oil depends very greatly on the kind of burner with which the test is made.

An article entitled 'The Magic Electric Home' (p. 165) contains an interesting description of a small house illuminated electrically by special fixtures and novel illuminating devices.

At the end of this number will be found the Trade Notes and the usual Review of the Technical Press.

TECHNICAL SECTION.

The Editor, while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.]

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p. 82, Vol. III.*)

Direction of the Test Plane.—Instead of going back to describe some of the illumination photometers which were invented during the development of my instrument, it would be natural, to go on to that of Mr. Haydn Harrison, who, having used one of my earlier patterns, has modified it in several respects and has produced his own photometer. One of his chief modifications was the abandoning of the horizontal screen, and the employment of one set at 45° in the instrument, but always used directly facing a lamp. He has recently added a horizontal screen which he finds necessary for certain purposes. This raises the question of the direction in which illumination should in general be measured, or to put it more explicitly, the position of the plane on which the illumination to be measured is received.

M. Wybauw of Brussels, one of the earliest writers on the distribution of illumination, contributed to the correspondence on my paper of 1892 to the Proceedings of the Institution of Civil Engineers.*

He criticised my treatment of the subject, and stated that: "It was not important in practice to know the illumination of any portion of a horizontal surface. The useful effect which a source of illumination could produce at the place under consideration should be ascertained. Particular data, such as horizontality of the surface, should, therefore, not be introduced into the calculations. It was desirable to assume any body whatever, having any kinds of faces—horizontal, vertical, or inclined—in the given position; better still, a spherical material point." M. Wybauw added that "the useful effect of the illumination produced by a ray of light should be considered as quite independent of the bodies or surfaces upon which it fell. To deal exclusively with the useful effects produced upon the horizontal faces of bodies, and to neglect those upon the vertical or inclined faces, was to commit an obvious error. It was the sum of all those effects which constituted the real value of the illumination furnished by the source of light."

Against this view, the opinion of Herr L. Bloch* of Berlin may be quoted. Writing of calculations and of measurement of illumination, he says: "The figures in question must refer either to the horizontal intensity, *i.e.*, the brightness on a horizontal plane in lux (metre-candles) or in the vertical light intensity, *i.e.*, the brightness on a vertical plane in lux. If we regard it as the main purpose of street illumination to enable us to recognise objects on the ground, or to read a letter or a map of the city, &c., then the horizontal intensity is to be considered; if, however, we wish to be able to distinguish, for instance, the faces of approaching people, the vertical intensity is to be

* Vol. CX., p. 147.

* Elektrotechnische Zeitschrift, May 24, 1906, and the *Illuminating Engineer of New York*, Vol. I, p. 580.

taken into consideration. Both points of view are of equal weight; hence other reasons must decide it. But the horizontal intensity has the decided advantage because it gives in all places on the ground only one simple value; while vertical intensity may have several entirely different values for the same place, according to the direction in which the vertical plane faces. The face of a person may be very brightly illuminated if it is turned towards the next lantern; but if that person should turn his back towards the lantern his face might no longer be distinguishable, although he still remains in the same place, since the other lanterns are comparatively far away from him. Hence the vertical intensity is not suitable for judging street illumination,

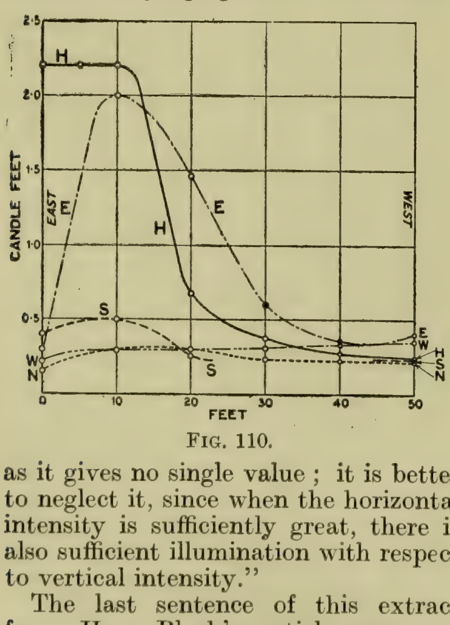

Fig. 110.

as it gives no single value; it is better to neglect it, since when the horizontal intensity is sufficiently great, there is also sufficient illumination with respect to vertical intensity."

The last sentence of this extract from Herr Bloch's article expresses in other words my reply to M. Wybauw's criticisms. I referred to a diagram which has been produced as Fig. 43* in these articles, and pointed out that the three curves, $\cos^2 \theta$ (for a plane always facing the light), $\cos^2 \theta \times \sin \theta$ (for a vertical plane), and $\cos^3 \theta$ (for a horizontal plane) ran fairly together, and that I had taken the lowest one.

Turning from the theoretical to the practical way of regarding this question, it is clearly possible for anybody who has a suitable instrument, to measure illumination with the screen set at any desired position. Mr. Roger T. Smith of the Great Western Railway, soon after providing himself with one of my illumination photometers, made some tests of illumination with the screen set vertical. His results are shown in Fig. 110. The curve H represents the illumination received on a horizontal screen, N on a vertical screen, facing north, S on a screen facing south, E and W on screens facing east and west.

There is very little difference between the mean of the illuminations on the vertical planes at the point midway between the two lamps, and the illumination of the horizontal plane at that point. At 20 ft. from the East lamp the mean of the four vertical measurements is ·575 foot-candle, while the horizontal illumination is ·68. But the paradox is to be found immediately below the lamp, where its own illumination on a vertical plane disappears, and the four measurements, having a mean of 0·27 are due to the light received from distant lamps. At this spot, the most brilliant illumination of all, namely, that due to the lamp overhead, is found on the horizontal plane. If these four sets of tests of vertical screens facing north, south, east, and west, are to be taken as measuring the illumination of this part of Paddington Station, what is to be done with them? Not even a dancing dervish can enjoy them all at once. It may be safely asserted that if the illumination received on a horizontal plane is good, the general illumination will be sufficient.

Two reasons seemed to have weighed with Mr. Haydn Harrison for inclining his screen at 45°, and using it, generally facing a lamp. One of these is the difficulty of measuring feeble illuminations, and the other, that he really wishes to measure candle-power in the first place, and is content to calculate the illumination due to each lamp and to add these together.

The difficulty of measuring feeble illuminations has been alluded to. Thinking that my records of measurements of 0·005 foot-candle in 1892

* Vol. I., p. 625.

might have been due to the enthusiasm of inexperience, I have asked Mr. A. A. Voysey, who has used my photometer for official tests in the City of London, for his experience of the measurement of feeble illuminations. He tells me that with the earlier pattern illustrated in Figs. 93 and 94 he has recorded readings as low as 0·003, with a note that they were roughly estimated, but he has frequently taken readings of 0·01 to 0·007 and has regarded them as sufficiently correct. With the Everett, Edgcumbe pattern he considers 0·02 is the lowest practical reading, but sees no reason why it should not be altered to read lower, though he doubts if it is necessary. This testimony is interesting because Mr. Voysey advocates a specified minimum of 0·05 foot-candle for the lighting of side streets. At these low illuminations, not only does the Purkinje effect have full play, rendering any photometric tests of doubtful accuracy, but much of the illumination is due to reflection from neighbouring buildings.

The Use of Coloured Screens.—When the colour of the light received on the perforated screen differs from the colour of the small lamp which illuminates the moveable screen, there is some difficulty in making an approximate balance, and a considerable difficulty in making an accurate one. But the difficulty is not so great as at first sight appears. Of course, it is of no use to search for a position of the handle in which the slot disappears. When the best possible balance has been made the colours are as apparent as ever, but the question is, Can the balance of brightness be improved? Turning the handle one way makes the slot manifestly brighter than the screen, and turning it the other way clearly darkens the slot. The handle should be turned quickly with decreasing range, and should then be stopped at about the middle position. With a little practice it is easy to reproduce the balance within 3 or 4 per cent. Some people find a greater difficulty with coloured lights than others, and those who are accustomed to fairly exact photometric work with lights of similar colour are among those who complain most of the uncertainty.

If the light to be measured is yellow, as that of most flame arc lamps, one of a set of yellow moveable screens may be used in the photometer, or the perforated screen may be bluish. The former has the effect of reducing the range of the instrument and the latter of increasing it. It is then easy to obtain a balance, but it only evades the difficulty during work, and it is necessary to find the coefficient applicable to each screen at leisure in the laboratory from the mean of a number of tests or by some other method unsuitable for outdoor work. It is possible to colour a pair of screens which counteract each other, but such a pair give a perfect match only for one kind of light. Messrs. Everett, Edgcumbe & Co. have supplied such screens with my photometer, but they find that most workers prefer to use white screens. For the measurement of daylight a yellow perforated screen is necessary.

So far, the use of yellow screens has been suggested merely for the purpose of bringing the illumination of the bluer light to match the yellower, but such screens have another advantage, and one based on a different principle. When a body becomes incandescent, red light is the first to appear, and is followed by orange, yellow, green blue, and finally violet light. Crova found that if the rate of increase of any one of these colours be watched in a spectroscope, only one of them appears to increase at the same rate as the total luminous radiation. This colour is in the yellowish green. He suggested the use of a glass tank containing a coloured chemical solution which would cut off all light except that of the particular colour. But this cuts off so much light that the method is almost useless for ordinary purposes. His principle has a sound scientific basis, and I propose to return to the subject of colour photometry after I have carried out certain experiments. It is sufficient to say at present that since the difficulty is really not so very great it is enough to apply the Crova principle partially, and to use a yellow tint both for the inner moveable and for the outer perforated screen.

The range of an illumination photometer may be increased by tinting the

perforated screen or test plate with a neutral grey. Place the instrument so that it receives an illumination of 3 foot-candles. Take an artist's stump and some fine charcoal powder, and lightly rub the screen. The slot will of course appear brighter. Turn the handle back to obtain a balance, and proceed cautiously shade by shade until the pointer indicates 1·5. The range is then doubled. If the screen is darkened until a balance is obtained at 0·6, the range is 5 times as great, and it may be pushed until the reading is 0·3, when the range is increased 10 times. With such a screen no accurate work at feeble illumination can be done. For permanent use the tint should be imitated with Indian ink. In the case of a white screen it is easy to see if it has become soiled, but discolouration of a tinted screen can only be detected by test. When I was using the instrument illustrated in Fig. 92 I carried half-a-dozen screens of different tints and colours.

(*To be continued.*)

Illumination at the Royal Institution.

On Thursday, Feb. 17th, Professor S. P. Thompson, D.Sc., F.R.S., delivered the first of his series of three lectures on the subject of 'Illumination, Natural and Artificial.'

The first lecture dealt largely with photometry, standards of light, and radiation. Some specially effective experiments were shown illustrating, on a large scale easily appreciated by the audience, various forms of photometers, such as the simple Ritchie wedge, the "grid" and "slot" photometers, and the Joly paraffin-block apparatus. Even the Lummer-Brodhun arrangement was exhibited to the audience by the ingenious device of forming an image of the illuminated field of view, by means of the telescope lens, on a sheet of paper held outside the photometer. Some reference was also made to the different qualities of light from different illuminants and a table exhibited showing the relative proportions of red, green, and blue in the spectra of different sources.

Another series of lectures is being delivered on Saturday afternoons by Prof. Sir J. J. Thomson, M.A., D.Sc., F.R.S., &c., on the electro-magnetic theory of light. A number of experiments were shown by the lecturer illustrating the wave-properties of light, the formation of nodes by interference, and other phenomena generally regarded as characteristic of wave-motion.

More Experiments on the City Lighting.

We understand that at a meeting of the Common Council, held on Thursday, February 17th, the Chairman of the Streets Committee submitted a report with regard to further experiments on the lighting of thoroughfares in the City of London. Offers were submitted from the City of London Electric Lighting Co., and the Gas Lighting & Coke Co., to carry out further experiments. The report was adopted without discussion and the Committee decided to make arrangements for the lighting of a number of thoroughfares.

This is so far satisfactory in that it shows that the Committee proposes to utilise the experiences of their Continental tours. We have, however, a recollection of so many efforts of this kind in the past not apparently leading to any conclusive result, and we should like to inquire once more what the actual object of these experiments is to be? We hope that in conducting these experiments the Committee have a very clear conception of what it is they wish to find out, and that their researches will lead to something more definite than in the past.

The Distribution of Energy in the Spectra of Commercial Illuminants.

By W. W. COBLENTZ.

(The following paper has been kindly presented by Dr. W. Coblentz, of the Bureau of Standards, Washington, U.S.A., as a communication for discussion at the hands of The Illuminating Engineering Society. The paper is an exceptionally exhaustive one, and will be continued in subsequent numbers of this journal. It is hoped that a special opportunity for discussion will be provided when this paper has been concluded. Meantime we shall be glad to receive any communicated remarks on the subject, which we will subsequently submit to Dr. Coblentz for final comment.—ED.)

(*Continued from p. 88.*)

EMISSION SPECTRA OF METALS.

To prove that osmium shows no bands of selective reflection, a filament of this metal was mounted in a glass bulb with a fluorite window. Two spectral energy curves are given in Fig. 4, curves *a* and *b*. The corresponding temperatures, observed with an optical pyrometer, using red absorption glass, were 1607° and 2000° K·66 μ C. respectively, while the computed temperatures (on the assumption that the radiation constance are the same as for platinum) λ *max.* = 1·35 and 1·2μ respectively) were 1670° C. and 1907° C. It will be observed that the curves show no indentations (or protuberances) such as will be noticed presently in the electrical insulators. As was mentioned in a previous paper,[1] the marked selective emission of metals must fall in the visible spectrum since all metals (thus far examined) have a low reflectivity (high absorptivity, hence high emissivity) in this region of the spectrum. On the other hand, all the metals have closely the same reflectivity in the infra-red, hence their emissivity must be close the same in the infra-red.

Since this paper is to some extent a commentary on recent work on radiation, it is not out of place to consider the absorptive (and hence emissive) properties of metals in the colloidal state, particularly of platinum. Recently Féry[2] investigated the absorptive properties of platinum black, which is usually employed (with soot) as a covering for thermocouples and bolometers. According to his observations, the deposits of platinum black

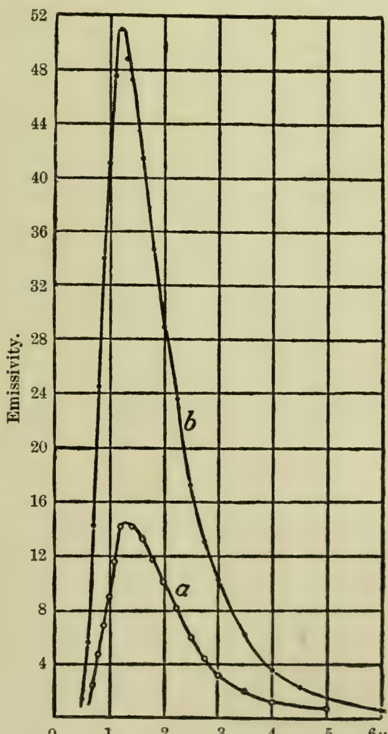

FIG. 4.—Radiation from Osmium.

showed a marked selective reflection in the region of 6 to 7 μ. Now it is possible to obtain electrolytically all sorts of deposits of so-called "platinum

[1] (This Journal, December 1909, p. 839.)

[2] Féry, *Compt. Rend.*, 148, pp. 777, 915, 1909; *Illuminating Engineer*, 2, p. 708.

black," varying from a greenish-brown to a fairly deep black; the former resulting from the employment of an excessive current density. The perfectly black deposit is an insulator, while the less black deposits have a fairly high conductivity, so that after covering a bolometer strip electrolytically with semi-metallic greyish-coloured platinum, the resistance is decreased by 1 per cent or more. The semi-metallic greenish-black and grey deposits would never be used in bolometers. For the perfectly black ones Féry's observations are practically the same as those of previous observers, who found that platinum black absorbs most in the long wave-lengths and lamp black absorbs most in the short wave-lengths. It is, therefore, the custom to cover the bolometer with platinum black and smoke the same over a candle. Since it is very difficult to obtain a uniform deposit of platinum that is perfectly black, the writer paints his bolometer strips (the exposed side) with a mixture of chemically precipitated platinum black and lamp black, which is then smoked over a paraffin candle containing a little rosin or turpentine.

Emission Spectra of Oxides.

Turning from the *metals* in which the *emissivity is low* (due to the fact that the absorptivity is low and the reflectivity is high) to the *non-metals*, "insulators" or "transparent media," in which the *emissivity is high* (due to the fact that the reflectivity is low, and the absorptivity is high, provided the layer of the substance is of sufficient thickness) we find an entirely different type of spectral energy distribution. Probably the most conspicuous example is the mixture of oxides used in the Nernst glower. At low temperatures the spectral energy distribution consists of two maxims, at 3 μ and 6 μ respectively, the latter being the more intense. With rise in temperature the bands in the shorter wave-lengths grow rapidly in intensity, so that the region at 6 μ becomes quite insignificant in comparison. This is well illustrated in Fig. 5, which gives the distribution of energy in the spectrum of a 110-volt glower when operated on. $a = 2$, $b = 3$, $c = 4{\cdot}2$, $d = 6{\cdot}2$, $e = 7{\cdot}1$, and $f = 10{\cdot}6$ watts respectively. On a still greater energy input, hence higher temperature, the emissivity increases at an enormous rate as compared with the infra-red, so that on normal operation the luminous efficiency is very high, in spite of its low reflectivity (high absorptivity and emissivity) throughout the spectrum. This is illustrated in Fig. 6, which gives the spectral emissivity of a 200-volt glower on $a = 19{\cdot}6$ watts and $b = 102{\cdot}5$ watts respectively. Curve b is drawn to 1-10th the scale of curve a. Temperatures observed with an optical pyrometer

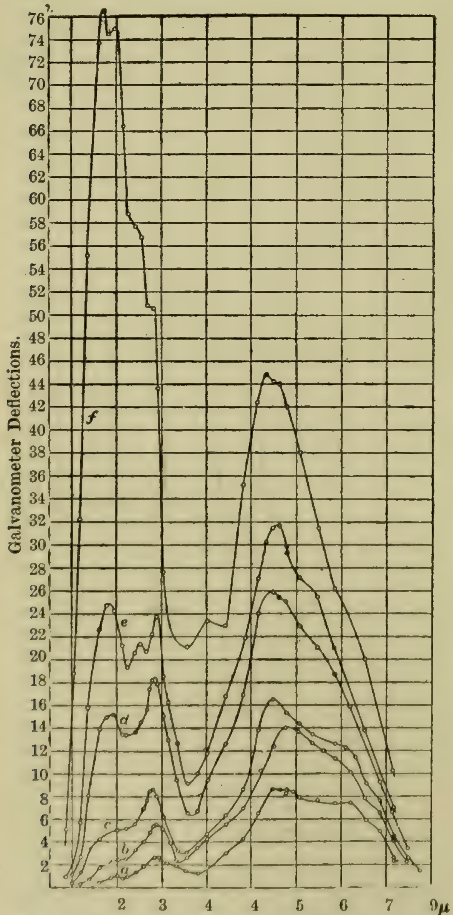

FIG. 5.—Emission Spectrum of Nernst Glower, $a=2$, $b=3$, $c=4{\cdot}2$, $d=6{\cdot}2$, $e=7{\cdot}1$, and $f=10{\cdot}6$ watts respectively.

with red glasses were respectively 1460° C. and 2055° C. Aside from its usefulness as an illuminant, this form of radiator has many applications in physical investigations. The difference between the radiation from a thick rod of oxide and the same material used in a gas mantle will be noticed on a subsequent page. It may be added that not all solids of this class exhibit this property of a gradual merging of the emission bands into a continuous spectrum. For example, it has been found that silicates of the feld-spar group have emission bands which are

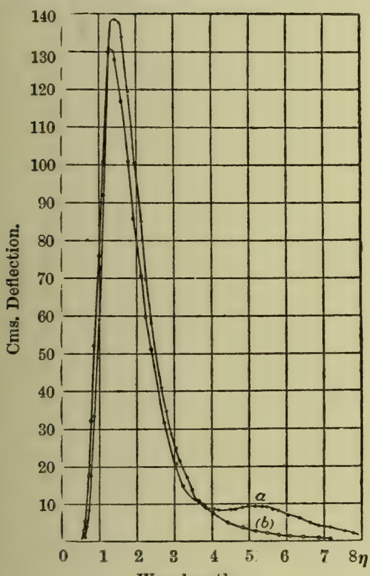

FIG. 6.—Emission Spectrum of Nernst Glower (*a*) = 19 6 watts, (*b*) = 102 5 watts, λ_{max} = 1·4 μ and 1·32 μ respectively.

as sharp as those found in gases; and they remained sharp up to the highest workable temperatures with no marked background of continuous spectrum. On the other hand, the exide of zirconium has a sharp emission band at 4·3 η, which does not shift or broaden with rise in temperature (Fig. 7), and remains superposed upon the background of continuous spectrum which goes through the cycle observed in the Nernst glower.[5] In other exides the sharp emission bands were found to blend into a continuous spectrum with rising temperature. A remarkable illustration of the variation of emissivity with thickness of the emitting layer is found in the Welsbach gas mantle, which consists of 99 per cent thorium oxide and 1 per cent cerium oxide, and the same material formed into an electrically heated rod, 1·2 mm. thick. In Fig. 8, curve *a* gives the spectral energy distribution of the electrically heated rod, and curve *b* (data from Rubens) the energy distri-

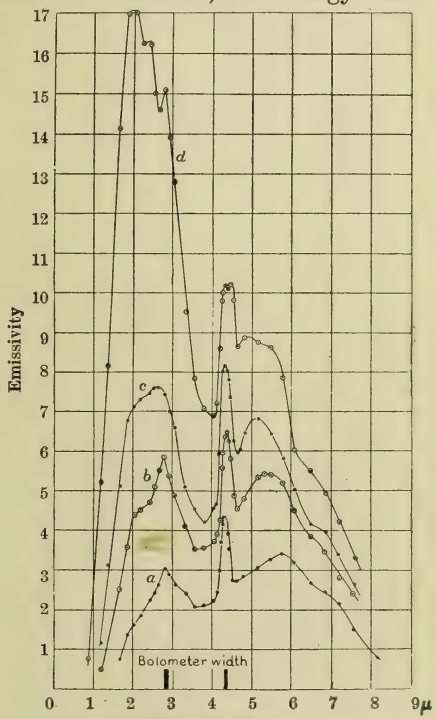

FIG. 7, Zirconia.

bution of the gas mantle. The vertical scale of the heated rod is reduced to about one-third that of the mantle. The rod was operated on about 1·5 watts per candle. Rubens[6] observed that when the amount of cerium oxide exceeded about 2 per cent, the mantle emitted a great deal more energy in the region of 2 μ, and the luminous efficiency was greatly reduced, due to this greater emissivity and consequent lowering of the average temperature of the mantle. Early writers held that the emissivity of the gas

[5] For further examples, see Bulletin, *Bureau of Standards*, Vol. 5, p. 159.

[6] Rubens, *Ann. der Physik* (4) 18, p. 725, 1905; 20, p. 593, 1906.

mantle is a luminescence phenomenon—*i.e.*, there is radiation in excess of the emissivity that is possible, due to the temperature of the mantle and to the emissivity of the mixture of oxides. That the luminosity of the gas mantle is due principally to thermal radiation appears from the following consideration. The temperature of the Bunsen flame is about 1750° C., which is sufficient to impart a temperature of 1500° to 1600° C. to particles of oxides provided their emissivity is not excessively great in the infra-red. In the gas mantle these conditions are fulfilled by the thorium oxide (a white oxide) which has a very small absorptivity with no bands of selective absorption, and hence well adapted as a support. The cerium oxide is buff coloured, absorbing the most in the violet, blue, and green, just as is true of copper from which it differs in this important property, viz., its emissivity is a function of the thickness instead of its reflectivity. The gas is able to impart to it a high temperature, since the quantity of heat lost by radiation is small, due to the fact that the emissivity is small in all regions except the visible, where it is practically saturated. Increasing the amount of ceria increases the effective thickness of the radiating layer, and a more saturated radiation is produced in the infra-red with a consequent lowering of the temperature and luminous efficiency of the mantle as observed by Rubens. That the thickness of the radiating layer (keeping the quantity of serium constant) has considerable effect on the efficiency is apparent from the electrically heated rod where the infra-red radiation is far in excess of that of the gas mantle.

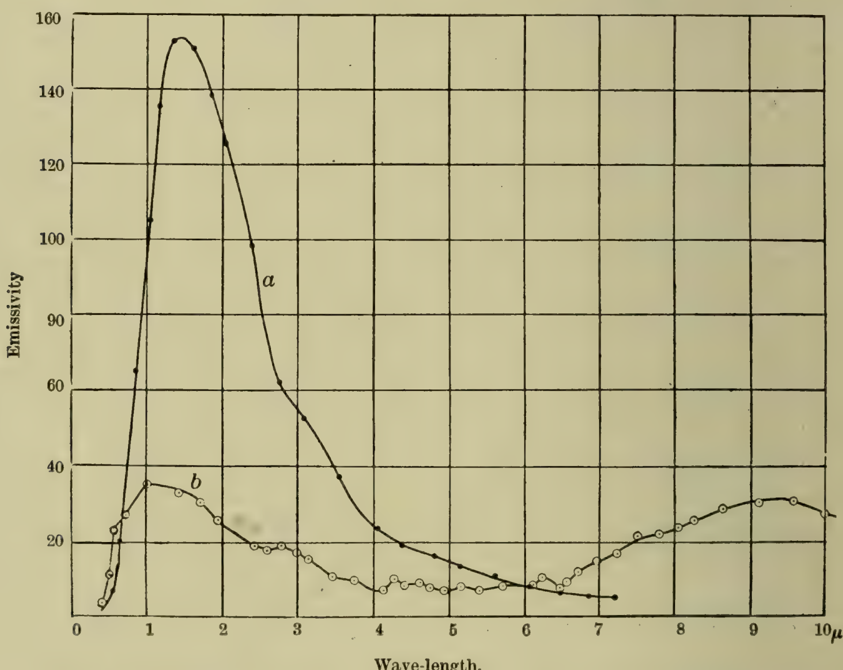

FIG. 8, a, Spectral Energy Distribution of electrically heated rod of material used in mantles.
b, Spectral Energy Distribution of incandescent mantle.

(*To be continued.*)

An Utopian Scheme of Streetlighting in the 18th Century.

By An Engineering Correspondent.

History is full of cases of optimistic inventions which were intended and credibly believed to be about to accomplish wonderful results, but appear to us at the present day ludicrous in the extreme. The history of lighting appliances is no exception. We may recall the man who proposed to illuminate the streets by the aid of a series of bottles in which the light of a candle was reflected over and over again. The inventor reasoned that each new reflection practically constituted a new candle. What could be easier, therefore, than to substitute bottles for candles ? And he appears to have been actually successful in getting his project seriously considered.

The present case, however, is one which, from its lofty aim, should specially appeal to us to-day. The inventor desired nothing less than the concentration of the innumerable sources of light illuminating the streets of London in one powerful unit to spread its rays over the whole city. Whether this dream can ever become reality in the future it might perhaps be rash to prophesy. We, at any rate, who have seen the development of the modern intensely powerful concentrated sources, hung high up in the streets are appreciably nearer the realisation than those who lived in the times of Mr. Le Fevre the "ingenious artist" in question. It may be added that it is interesting to observe that the inventor desired to bring his device be-before the notice of the Society of Arts, a testimony to the sympathetic attitude of this society to illumination even in those early days. The following letter is taken from *The Gentleman's Magazine* (Vol. 33, 1763), and is addressed to the Editor, Mr. Urban. :—

"Mr. le Fevre, a very ingenious artist, having observed that many towns and villages were so dark and dirty in the winter time, and the streets leading to and from them generally so narrow and ill-paved, as to make it dangerous for strangers to travel through them in the night ; and considering, that by reason of the poverty of many of the inhabitants in the worst and most inconvenient streets, they could not be illuminated unless at the public expense, he applied himself to contrive such a kind of lamp as to give light at small expense, not only to a single street, but to a whole town provided the same be so situated, that a proper elevation may be obtained, on which to erect this lamp.

"As this ingenious contrivance may undoubtedly be turned to general utility, it is hoped, the Society of Arts will not think it below their notice ; but that, as the expense will be inconsiderable to such a body, they will at least make one trial, on the success of which the whole community may then venture to proceed. I have herewith sent you an accurate drawing of the whole, by which a model may be made by an experienced workman.

And am, Sir,

Yours, &c.

Explanation of the Plate (p. 161).

"A B C D in the uppermost figure are four large concave paraboloids. In the lowermost side of each of these, nitch or hollow G as in the lateral figure, to contain the oil, and on the uppermost side a funnel H in the same figure to let out the smoke. These four speculums being so framed, as that their funnels should all unite in one common tube, and placed upon a pedestal, as in the lowermost figure, in the widest and highest part of any town or village.

"There is reason to believe the light will extend to a considerable distance, for the reflexion from these sort of vessels being always parallel to the

axis of the parabola, the light reflected from them, will extend itself in the like direction, by which means the places at a distance on each quarter of the lamp, will be better lighted than those that are near it. If it be placed at a moderate height, the benefit from it will be the more general, otherwise the parts of the town that are most remote will be sufficiently lighted, while those that are near will receive little or no benefit.

"M. le Fevre, at first, proposed that his vessels should be made of tin, and that the outward extremities should be open or covered with glass only, to prevent the lights being extinguished by the winds ; but as there appears no difficulty in getting glass-vessels cast in any form and of a magnitude too sufficient to answer the purpose, a more transparent kind of glass may be so framed as to cover like a drum-head, the widest extremity of the vessel, and the body of it may be of a coarser sort, such as is used by gardeners, &c. There appears no difficulty in contriving a way to put in the oil, without taking off the covering, which would subject the lamp to frequent accidents. The hint to the society is sufficient, which there is no doubt they will approve, if it appears to them of importance enough to merit their attention. Yours, &c."

Utilization of Lamp-Posts for Various Purposes.

We notice in a recent number of *The American Gas Light Journal* some interesting remarks on the uses to which gas lamp-posts are now being put in the United States.

One of the first developments consisted in a plan of attaching letter-boxes to certain lamp-posts in the City ; the postman calling to collect letters naturally found the light of service. As years went on the fire brigade began to utilize lamp-posts for fire alarms, signal-boxes, &c., and a little later the method of attaching signs indicating the title of streets to corner posts was introduced ; this latter device was naturally of considerable service to strangers in the town.

But of late years the system of attaching notices on lamp-posts has developed in many directions. For instance, in many of the summer entertainment-parks the lamp-posts at the entrances almost resemble Christmas trees—so fully are they utilized to describe the delights inside ! In addition, the value of lamps for advertisements is becoming very generally appreciated, and they are in existence certain companies who pay a certain sum to the City for the exclusive use of each lamp in certain parks and streets, &c. Such companies commonly draw up a chart mapping out the position of serviceable districts which they sub-let for advertisement. Isolated lamp posts are in very little demand, but those in front of well patronized shops are frequently sub-let by the company to the owner of the shop, while lamp-posts in the neighbourhood of theatres are also naturally in great request.

In addition it is now becoming customary to use lamp-posts as index signs indicating entrances, exits, the locality of drinking fountains, &c.

One point, brought out by our contemporary is that this development has been brought about by the increase of brightness in the modern sources of light. The old illuminants were too dim to be of much service. But transparent signs, illuminated by the powerful lights of to-day, can be made very prominent and noticeable objects.

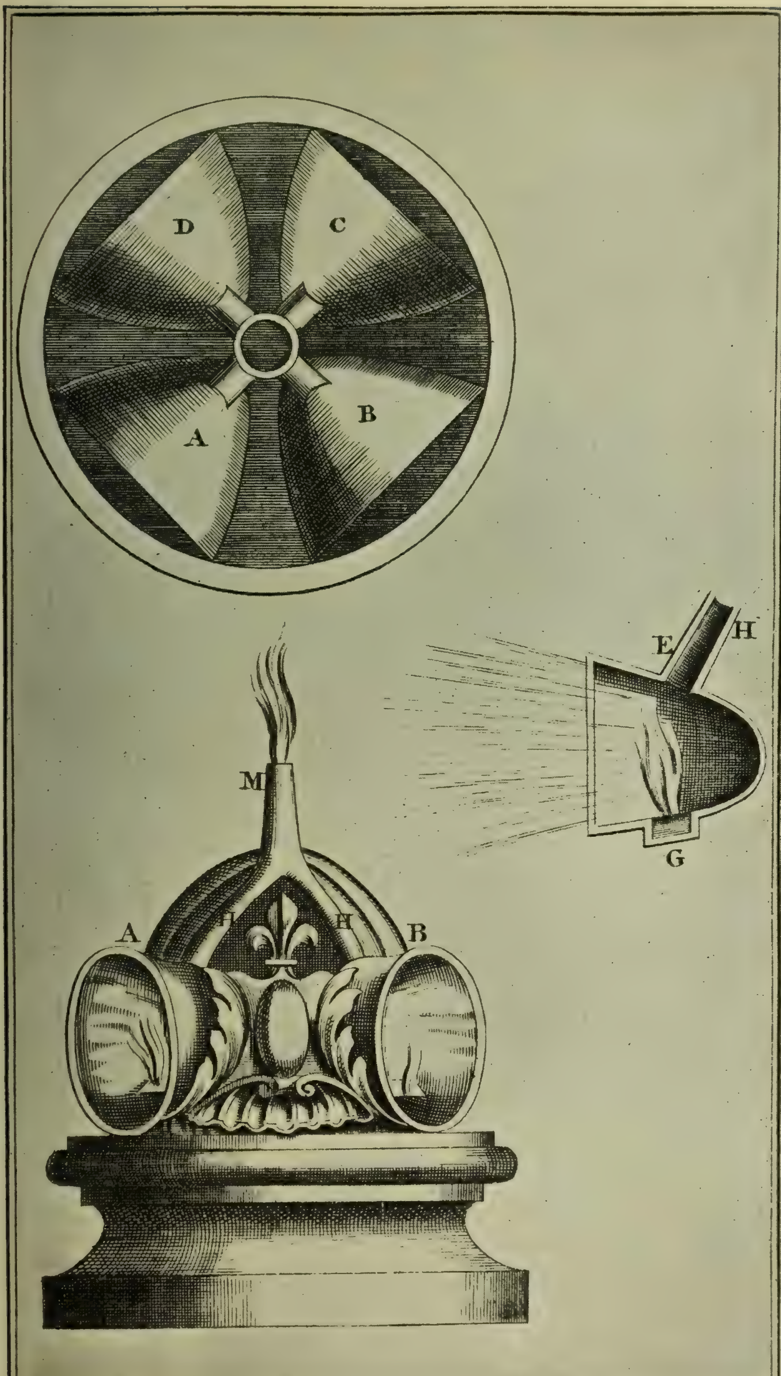

FIG. 1.—A concentrated source of light intended to illuminate the entire City of London (M. le Fevre 1763).

The Lighting of the Patent Office Library.

By an Engineering Correspondent.

The illustration on the opposite page shows the method of lighting employed in the Patent Office Library at the present time. During the day time the illumination is derived from a large central sky-light which provides the illumination for the reading tables down the centre of the room. When the artificial lighting of the building was originally arranged, however, a different system of lighting was provided, the chandeliers being placed not over the central table, but down the gangway as shown (at this time there were no reading lamps on the central table as there are now). The result was that, however necessary such a system might be considered from the architectural standpoint, the illumination on the reading tables midway between chandeliers was extremely poor; on the other hand, the illumination of the gangway immediately beneath the rows of chandeliers was somewhat extravagant.

Realizing eventually that some further system of lighting was needed, the authorities determined to equip the tables with short standards, each having two lamps as shown. The first step was an installation of naked lamps only partially covered by opal glass shades. This was naturally a very imperfect arrangement, since the shades did not concentrate the light well and the naked filament was distressing to the eyes of the readers. Strong representations were, therefore, made that some more scientific system was necessary, and it was decided to equip the tables with lamps with frosted tips and Holophane reflectors. It then transpired that the height and position of the stand had been fixed without any reference to the shades which were to be employed. As a result, full advantage could not be taken of the merits of the Holophane shades, since the proper combination of lamp and fitting could not readily be applied to the existing conditions.

As a compromise, therefore, cardboard shades were fitted at the base of the glass ones so as to completely screen the lamps, and this arrangement is visible in the illustration.

The present system has, therefore, been arrived at merely by a series of compromises. It is a great improvement on the original conditions, though probably yet more perfect arrangements might have been made had the whole system been planned out with reference to the fittings to be employed.

The history of the change of lighting in this building is, therefore, rather interesting, and perhaps typical of the different considerations which will occur in many public buildings. It may be added that it was only after considerable delay, and after the need of a better illumination had been realized by many of those habitually using the library, that these changes were made.

In addition, there still remain other points which might profitably receive attention. For example, we think most people would agree that the arrangements of lighting in the various alcoves where the shelves of books are kept, could be improved. In such cases it is necessary to illuminate the backs of the books so that the titles can be easily read, and at the same time to arrange the sources of light so that anybody searching for a book is not dazzled by encountering the glare of naked filaments. We hope that this and other matters will receive careful attention at the hands of the authorities very shortly.

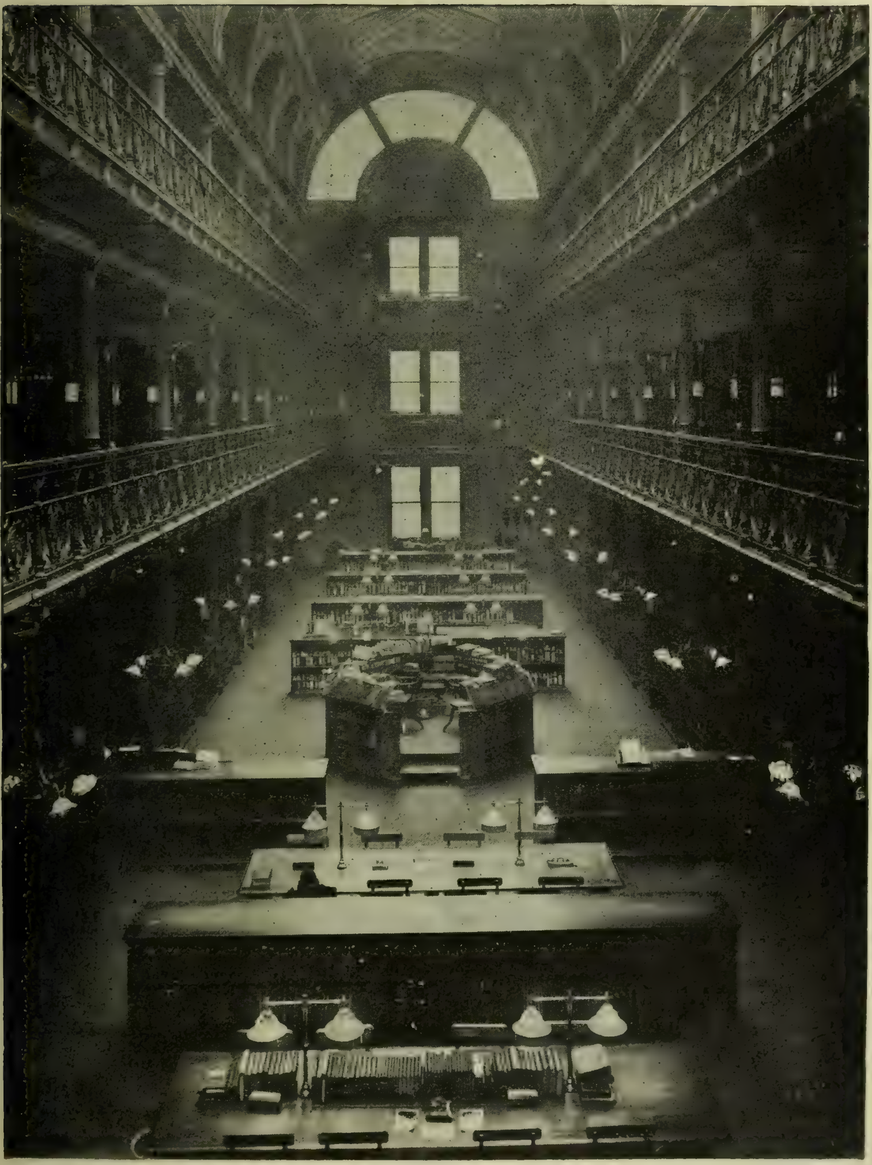

FIG. 1.—Illustration of Method of Lighting the Patent Office Library (London). The lamps on the central tables have been recently added.

(Thanks are due to the courtesy of the authorities at the Patent Office Library for permission to reproduce this photograph.)

Modern Arc Lamps and their Application.

By A. Angold.

(*Abstract of Paper read before the Association of Engineers-in-Charge, London, on February 9th*, 1910.)

The author prefaced his paper by a discussion on the general physical principles of the electric arc, and the conditions which must be met in order to make the arc as staple and luminous as possible. In this connection he referred to the use of a core both to steady the arc and to add to the efficiency. In flame arcs compounds of the metals calcium and titanium are used to produce a golden and white light respectively. Reference was also made to the rate at which flame carbons burn away and the advantages of the magazine lamp in which carbons are replaced automatically; the labour of trimming is also very considerably reduced, as it is unnecessary to remove long waste ends. Another incidental advantage is that contact can be made with carbons quite near the arc, and the fall of pressure along them thus reduced to a minimum. Mr. Angold added that the magazine lamp was trimmed with 10 pairs of plain 12-inch carbons and burns for 50 or 60 hours. The same quantity of metal-cored carbon would be 50 per cent dearer.

The author also referred to the tendency to try to run as many arc lamps as possible on a given voltage. To some extent this was a gain, but frequently the introduction of an extra lamp decreased the light given by the others. When lamps are run in series some form of automatic cut-out is needed.

The author next described the various types of simple control, including the use of a hot-wire, which, however, is apt gradually to deteriorate. Another form of lamp which was mentioned was the enclosed lamp, containing two arcs in series within the globe. Such a lamp could be connected directly to a circuit of 200 to 250 volts.

Continuing, the author gave the following figure relating to modern arc lamps:—

	Watt.
For single enclosure with an opaline globe	.91
Open-type lamp with opaline globe	.77
Vertical carbon flame lamp, using heavily mineralised carbon with opaline globe ..	.3
Inclined-carbon flame lamp with opaline globe	.3

Reckoning 20 per cent. loss on the globe in all cases.

The angle of maximum candle-power below the horizontal, also with opaline globe, is given as:—

For single enclosure lamp ..	30°
Open type	42°
Vertical carbon flame ..	38°
Incline flame	70°

In conclusion the author summarized the relative advantages of small arc lamps and high candle-power Tungsten incandescent lamps. He added that he did not agree with the general impression that for street lighting a strong horizontal illumination was needed. Light of this kind was apt to stream into the eyes of pedestrians, and he thought it was preferable to use lamps the intensity of which, at small angles to horizontal, was comparatively low, and to place them high up out of the range of vision.

The Ex-Sultan of Turkey and Illumination.

A recent number of *T.P.'s Weekly* refers to the preference of the ex-Sultan of Turkey for bright lights.

"During the last few weeks," this journal says, "the ex-Sultan has fallen almost into a condition of melancholia. One of the reasons for this is the impossibility of supplying him with all the artificial light he needs. At Yildiz he had always been accustomed to the nightly flare of 4,000 gas lamps and 2,000 electric lights. He had, in fact, a mania for this sort of illumination, so that now that he is reduced to a few score of electric lights in all, he feels his position keenly."

"A Magic Electric Home."

UNDER the above title *The Edison Monthly* for last September described some of the devices of an amateur electrician who owns a small villa in the suburbs of Boston. Now that so much more trouble is taken to keep the consumer in touch with developments in gas and electric lighting there is every incentive to companies to exercise their ingenuity in providing demonstrations not only of what a system of illumination can do in the every-day utilitarian respects, but also in contriving new and striking decorative effects. This, of course, is possibly even more applicable to demonstrations in shop windows which are intended to attract the casual passer by their novelty.

As a matter of fact it may be said that, apart from effects which might be considered too theatrical for the average home, the richer class of householder might often be induced to make more liberal use of light for decorative purposes if only he understood more perfectly how it could be legitimately applied. For example, the sole use of a source of light is often taken to be its use as a means of illuminating surroundings. Yet in many cases one could imagine delicately tinted or bizarre shades providing the chief *raison d'être* of a source of light.

FIG. 1.—"Den" and Cosy Corner.

In the case to which we refer, however, the electrician seems to have carried his fancy to exceptional lengths. Thus the drawing-room is provided with a series of concealed multi-coloured lights controlled by a dimmer, by the aid of which the shades of dawn, midday, and twilight and moonlight can be imitated. In addition quaint devices are met at every hand in the rooms visited. Thus the "cozy corner" of the den shown in Fig. 1 contains an animal's skull, which is arranged to wink with a luminous eye as the visitor sits down, and hammered copper incense burners have been converted into receptacles for small coloured lights concealed amid the draperies.

FIG. 2.—Music Room.

The Japanese umbrella to be seen in the corner of the music room (Fig. 2) again, is hung with electric lights, which are concealed in lanterns at its four extremities, the lights being operated by a switch in the place where the handle of the umbrella usually terminates. A concealed tubular light, placed over the piano, illuminates the keys and music. The chest to be seen on the left of the piano also contains an unsuspected novelty. It consists of a miniature theatre, in which the eruption of Vesuvius is reproduced, molten lava and all, by the control of electric lamps; electricity also raises and lowers the curtain at appropriate moments. The wiring of the desk on the left hand of this chest is also interesting, wires being carried through the thick posts of the desk to the copper brackets on each side. The large central shade shown in Fig. 1 is also unusual. It contains two tube lights each a couple of feet long, one amber and one blue.

The fixtures to be seen in the dining-room (Fig. 3) are also striking. From each corner of the room heavy copper chains descend and are stretched so tight as only to sag two feet from the ceiling. Through the centre of this chainwork is dropped a design, attached to the same type of chain, and resembling a Maltese cross in Flemish oak. From the centre of the cross hangs a large dome of copper polished on the inside and finished, like the other

fittings in "verdi," on the outside. It should be mentioned that the general scheme of decoration in the room is in harmony with the fittings, being in Flemish oak and red burlap, with verdi copper for trimming. The large dome contains a cluster of four lights. Other small lights in the room are covered with blue and amber shades.

We have only attempted to sketch above the main features of the lighting arrangements described by *The Edison Monthly*. It may be added, however, that the house is also stated to be exceptionally well provided with electrical hot water bottles, vacuum cleaners, and other up-to-date contrivances. And it is interesting to note that the work of installing these appliances has all been done by the ingenious owner of the house.

FIG. 3.—Special Ornamental Chain Fixtures

An Award for the Invention of "Euphos" Glass.

WE understand that Dr. F. Schanz and Dr. K. Stockhausen have been awarded a large silver medal by the Italian Ministry of Public Education in recognition of their investigations on the effect of ultra-violet light on the eye, and the invention of the Euphos Glass. This seems to be an interesting recognition of the importance of the study of the Physiological effects of light from the standpoint of public health.

The Illuminating Engineering Society.

(Founded in London, 1909.)

Recent Developments in the Measurement of Light and Illumination.

THE next meeting of the Illuminating Engineering Society will take place on **Tuesday, March 15th,** at 8 p.m., at the house of the Royal Society of Arts (John Street, Adelphi, London, W.).

On this occasion there will be a discussion on "Recent Progress in the Measurement of Light and Illumination." (*Illustrated.*)

In order to make the discussion as complete as possible it is again hoped that foreign members and others who are unable to be present, will send written contributions which should be in the hands of the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.) by March 12th at latest.

A series of queries on the subject has again been prepared in order to suggest a few points on which discussion would be valuable. Naturally this list is only suggestive, and discussion will also be welcomed on other recent developments in the subject.

It is hoped to make the exhibit of different forms of apparatus a special feature of the next two meetings.

As this is again a very wide subject, it is proposed to confine the discussion on March 15th mainly to the measurement of light, and to the underlying principles of the subject, and to proceed to discuss the more practical applications, such as the measurement of illumination in streets, factories libraries, &c. (see Queries 6, 7, 8), at the meeting of the Society to be held in April.

Members and others desiring to participate in the discussion are invited to send in their names to the Hon. Secretary previous to the meeting.

List of Queries :—

1. Are the courses of instruction and experimental facilities at technical colleges and scientific institutions for the study of photometry adequate, and what changes are desirable in the existing methods to suit modern requirements ?

2. What is the maximum sensitiveness (*i.e.* the smallest percentage change of illumination perceptible to the eye) at present obtainable from photometrical instruments in the laboratory ? How should this sensitiveness be tested and expressed, and to what extent does it differ in the case of different individuals ? In what directions may improvements be anticipated in the future ?

3. What are the best modern methods of obtaining the polar curves of light-distribution and of measuring the mean spherical candle-power of different sources, and what possibilities are there of simplifying and improving such processes in the future ? What are the best methods of deriving the mean spherical or mean hemispherical candle-power from such curves in the case of all illuminants ?

4. As it is desirable that there should be international agreement on the subject of the commonly accepted method of measuring and expressing the intensity of illuminants of all kinds in order that results referring to different sources may be comparable one with another, on what basis should such comparisons of illuminating power be made, and what information should be included in a report of tests of this nature ? Is it desirable that all lights should be compared in terms of Mean Spherical candle-power ?

5. What is the best method of comparing the intensity of modern sources of light which differ in colour ?

6. What are the main qualifications of an illumination-photometer for practical work ? With what degree of accuracy can the illumination in streets and buildings be measured, and what limits of accuracy should at present be permissible ?

7. Discussion of the exact value and significance to be attached to photometrical measurements in streets, and buildings, and the possibility of framing and carrying out a specification relating to the conditions of illumination in such cases. To what authority is it desirable that dispute regarding such specifications and photometrical measurements should be eventually referred ?

8. What are the best methods of studying and measuring daylight illumination ?

Illuminating Engineering Society

(Founded in London, 1909)

Glare, its Causes and Effects.

Discussion at a Meeting of the Society held at the house of the Royal Society of Arts (London) on Tuesday, February 15th, 1910.)

THE discussion on the subject of "Glare: its Causes and Effects," which had been opened by Dr. J. Herbert Parsons, F.R.C.S., at the last meeting of the Society, on January 11th, was resumed on Tuesday, February 15th, at the house of the Royal Society of Arts, the chair being taken by the President Professor S. P. Thompson, D.Sc., F.R.S.

The President having called on the Hon Secretary to read the minutes of the last meeting, proceeded to explain that, in accordance with the constitution, the Society was empowered to nominate each year as honorary members of the Society three gentlemen who had rendered distinguished services to the cause of illumination.

The Council had therefore approached the following authorities ; **Sir William Preece,** K.C.B., F.R.S., who had done such valuable pioneering work in connexion with the measurement of illumination ; **Sir Joseph Swan**, M.A., D.Sc., F.R.S., one of the inventors of the electric incandescent lamp ; and Prof. **A. G. Vernon Harcourt,** M.A., F.R.S., LL.D., &c., whose work in connection with photometry and standards of light was justly celebrated. Letters from Sir William Preece, Sir Joseph Swan, and Prof. A. G. Vernon Harcourt expressing their appreciation of the honour of becoming Hon. Members of the Illuminating Engineering Society were then read by the Hon. Secretary, as follows :—

DEAR MR. GASTER,—I am very sensible of the honour which the Illuminating Engineering Society do me by inviting me to become one of their first Honorary Members, and I have much pleasure in accepting their nomination.

Will you kindly convey to your President and Council my warm appreciation and thanks.

Yours sincerely,
J. W. SWAN.

DEAR GASTER,—The proposal to make me an Honorary Member is very gratifying and I appreciate it very much.

I accept the honour with great pleasure. Yours very truly,
W. H. PREECE.

GENTLEMEN,—I accept with thanks the honour you offer me of becoming an honorary member of the Illuminating Engineering Society.

I am, yours faithfully,
A. VERNON HARCOURT.

The President and the Hon. Secretary of the Illuminating Engineering Society.

The President then called on the Hon. Secretary to read again the list of names submitted for membership at the last meeting of the Society who would now formally become members, The Hon. Secretary then read the list of names* of these gentlemen, who were subsequently declared members of the Society. The Hon. Secretary also read out the names of the following gentlemen whose names had been submitted to, and approved by the Council for membership since the last meeting on January 11th :—

Ordinary Members.—Dr. W. M. Bayliss, M.A., D.Sc. (Oxon.), F.R.S., Prof. W. C. Clinton, Prof. R. M. Walmesley, D.Sc., F.R.S.E., &c., Dr. W. J. M. Ettles, M.D., Ch.M., F.R.C.S.E., Mr. R. M. Palowkar, Mr. J. H. E. Hart, Mr. H. J. Taylor, Mr. A. A. Ernst.

Corresponding Members. — Prof. A. Grau (Vienna), Dr. H. Lux (Berlin).

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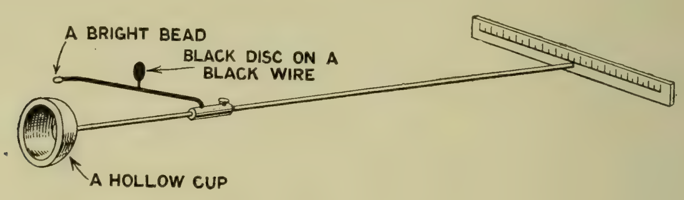
* See *The Illuminating Engineer*, Feb., 1910, p. 131.

The President then explained that the last meeting of the Society had been mainly devoted to the physiological aspects of "Glare," and that on the present occasion it was proposed to deal mainly with the more familiar applications of the subject. He then called upon Mr. A. P. Trotter to open the discussion.

Mr. A. P. Trotter then resumed the discussion on "Glare, its Causes and its Effects," which was opened at the previous meeting. The speaker said that he understood that the discussion that evening was to be mainly practical, but he would first like to deal with a physiological point. At the previous meeting the President had set them a problem, viz., whether the contraction of the iris, which caused a reduction in the area of the pupil was due to light entering the pupil, or to light falling on the cornea and possibly on the iris also. He had used an instrument which enabled somewhat rough measurements of the pupil to be made. This consisted of a scale at one end of a rod, fixed at a distance of easy vision. At the other end of the rod was a cup which fitted over the cheek-bone to fix the instrument relatively to the face. A little polished silver bead could be adjusted on the rod so as to be held very close to the eye. When this bead was strongly illuminated by a side light, out of view, a round bright disc was seen, which was the shadow of the iris thrown on the retina. (This could easily be seen by using the head of a pin or polished pencil case.) A little oval disc about 3 mm. by 4 mm. attached to the instrument was just large enough to hide the filament of a lamp at about three-quarters of a metre. Holding the instrument to the eye, the image of the pupil appeared to be about 80 mm. on the scale. When a bright lamp in front of the eye was switched on, the image contracted to about 60 mm. By a slight motion of the rod it was possible entirely to obscure the filament of the lamp, but there did not appear to be any material relaxation of the pupil—not 5 per cent. It seemed, therefore, that the contraction was largely due to the light falling on the cornea and the iris.



What "exactly" constituted a glaring system of illumination was a very difficult problem. Dr. Hyde had given as good a general definition as anybody when he said that it was an illumination which was painful or uncomfortable. But people had different ideas of discomfort. Intrinsic brilliancy was one of the factors of glare. He understood intrinsic brilliancy to be the ratio of the candle-power of a source of light to the effective area of that source. An ordinary candle flame measured about 2 ins. high as a triangle, and about 0·4 in. at the base (51 by 10 mm.), which gave about 2·5 candle-power per square inch, or 0·39 per square centimetre. It seemed to him that the candle flame was a good standard for ordinary indoor work. With higher intrinsic brilliancies for lights close at hand, the light was painful. On the other hand, the effect of brilliant light at a distance was a complicated matter, especially if the angles subtended were very small.

In estimating intrinsic brilliancy it was a mistake to calculate the area of the filament of an electric glow lamp by multiplying its length by its actual width, and to divide the area so obtained by the candle-power. Owing to irradiation, the width of a glowing filament appeared to be much larger. The glowing filament of a carbon 16 c.-p. lamp appeared to be about 1·5 mm. wide, or about ten or twelve times

its actual width, and for practical purposes it must be taken as the apparent width. Seen at a greater distance it appeared even wider, for at a few feet distance the separate turns of the filament could not be distinguished, and the filament looked like a solid glowing mass. Irradiation might be partly an optical phenomenon, very largely it was a functional matter which the physiologist could explain by spreading of the changes in the visual purple, and it might also be partly a subjective matter.

Coming to practical questions, Mr. Trotter said that there were two broad methods of lighting, one in which the source of light was within the range of vision, and the other in which it was practically outside it. In domestic work, lights had to be for the most part within the range of vision. Concealed lights in cornices were very charming, but they were very expensive. Domestic lights within the range of vision should always be shaded, the naked filament should never be seen. The intrinsic brilliance of the shade should not exceed one or two candle-power per square inch. In 1880, when the Swan and the Edison lamps first appeared, it had seemed to him that they would soon become so improved and would be so brilliant that they would be uncomfortable to look at. Thirty years had passed, and the carbon lamps were still used at about the same brilliance, though they now had metal lamps which were more brilliant. He thought that something must be done to reduce this anticipated brilliance, and he designed, thirty years ago, and about fifteen years too soon, shades of which he showed a specimen. The system had been developed since and improved as the holophane system. A 16 c.-p. lamp in such a shade gave a brilliant surface of about 7½ square inches, and allowing for loss, this gave about 4 candle-power per square inch. This was rather too bright.

For some years he had used a Holophane shade over his desk, hung at about 3 ft. above the table. It was of a pattern which concentrated the light downwards. But now that his eyesight was beginning to fail he wanted more light. He had recently changed it for a dark green shade at about 17 ins. from the table, shading the whole room and illuminating the table like an old-fashioned reading lamp. Dr. Louis Bell who was a very considerable authority on illumination, gave an illustration* of this mode of lighting "as a horrible example of what should never be permitted." This showed how difficult it was to lay down any rules in connection with this matter. Where lights had to be in the range of vision, as in a drawing-room or dining-room, he preferred placing the lamps close to a white wall, and using parchment paper shades. The effect was soft, and the illumination from a few lamps of small candle-power was surprising.

Mr. J. H. Agar Baugh said he would first describe a simple experiment. If the windows of a well-lighted room were covered with tissue or tracing paper the room, instead of appearing darker would appear distinctly lighter, specially in the darker corners. Mr. Baugh attributed this to the iris of the eye contracting to meet the glare of the sky. On the glare being removed the iris expanded and one could see better. However, he by no means desired to recommend the use of obscured glass for windows, except in positions subject to glaring light.

Turning to artificial light, Mr. Baugh added that though greatly admiring the method of lighting by reflection from ceilings it was apt to be too expensive for use in ordinary rooms. He had therefore tried to obtain equally good results as regards efficiency of illumination and absence of glare at a more moderate cost by using metallic filament lamps in ground glass globes, and both ground glass and opal globes and shades with incandescent gas burners. It was one of the most prevalent and mistaken impressions that diffusing light reduced *real* illumination. In Mr. Baugh's opinion the useful light was, as a rule much increased, not diminished by diffusion. Low power units such

* Dr. Louis Bell, 'The Physiological Basis of Illumination.' *The Illuminating Engineer*, vol 1, p. 416.

as single candles or 5 c.-p. carbon lamps, however, did not require diffusing shades so much.

A step in advance of even a diffusing shade or cover was the use of a perfectly opaque metal shade which completely concealed the filaments of the lamp or the mantle of the gas burner.

Such simple and extremely cheap shades used with either electric light or gas gave a most efficient comfortable light, and at a very low cost.

Mr. Baugh showed a gas burner of the "Bijou" type, which, he said, burnt only 1 foot of gas per hour, and gave all the light which could possibly be required on a workbench or table. The shades suitable for electric light were 10 in. diameter and 5 in. deep, or a 6 in. depth might be better. The shades for "Bijou" incandescent burners were 8½ in. diameter and 4½ in. deep. They were made in aluminium and also enamelled iron.

Mr. J. S. Dow mentioned that a letter had been received from Prof. A. Blondel (Paris) who expressed his interest in the subject and hoped to be able to contribute to the discussion shortly. Prof. Blondel added that his interest in the matter dated from when his recognition of the undesirably high intrinsic brilliancy of modern illuminants led him to undertake the design of "Holophane" shades and reflectors.

Mr. Dow then proceeded to read extracts from the communications of Prof. A. Grau (Vienna), Dr. J. Stockhausen (Dresden), and Messrs. Körting and Mathiesen (Berlin). (These communications will be found *in extenso* on p. 178.) In summing up the discussion he thought that there seemed to be general agreement that at any rate sources of higher intrinsic brilliancy than a certain limiting value ought not to be exposed in the direct range of vision. Dr. Louis Bell had suggested 2½ c.-p. per square inch for the permissible limit while Dr. Stockhausen and Prof. L. Weber had suggested values near 4½ and 2½ candles per square inch. Mr. Trotter's estimate, derived from the candle-flame, was in the same neighbourhood. This was very good agreement. On the other hand, Mr. J. E. Woodwell (*Trans. Illuminating Engineering Society*, U.S.A., 1908) and recently specified a much lower figure namely, 0·2 c.-p. per square inch.* *Added:—*

There seems to be a disposition to suggest that it would be enough if sources whose brilliancy exceeds this limiting value were placed high up "out of the range of vision," and that their use in interiors need not be regarded as undesirable if proper precautions are taken. On analysing the matter, however, it becomes evident that it is not easy to say exactly what is included in "the direct range of vision." If one is reading a book it seemed fairly obvious that no disagreeably bright light ought to be visible out of the tail of the eye. But in addition it is pleasant in any interior to feel that one can allow the eye to rove at will in any direction without the risk of meeting any undesirably bright dazzling object. The feeling of peace and "restfulness" of a room is largely dependent on ability to do this. It is also often very difficult so to arrange a source that it is not directly visible to some persons, in certain positions in a room. Therefore I sympathize with Dr. Stockhausen's suggestion that, on principle, sources having an excessive intrinsic brilliancy ought never to be used in rooms of moderate size.

In addition it would probably be conceded that any source of painfully high intrinsic brilliancy is not an artistic object. It is rather curious that people so often use sources of light just as they were turned out without reflecting that their appearance could be absolutely and agreeably altered from the artistic standpoint by the use of suitable shades, lanterns, &c. In reality the lamp itself should only be considered the "raw product."

Turning to the more physiological questions, it seemed to be recognised that the extent of the pupil-aperture of the eye is a very uncertain test of glare. Yet opinions on this point seemed to vary. Thus Dr. Steinmetz's

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* *The Illuminating Engineer*, London, vol. I., p. 938, 1908.

idea* seemed to be that the opening and shutting of the pupil is dependent mainly on the *energy* entering the eye, irrespective of wavelengths. If this were so one would expect the size of the pupil throughout the spectrum to follow the energy-curve of an illuminant. Yet Haycraft,† by a flashlight process, has found that it is almost identical with the luminosity curve. Dr. Stockhausen, again, seems to suggest that the diameter of the pupil-aperture is specially subject to the effect of infra-red rays, while his allusions to the influence upon it of ultra-violet light on the pupil-aperture if rightly understood by the writer, seem inconsistent.‡

Dr. Stockhausen's suggestion, regarding the study of "after-images" as a criterion of glare is interesting. Presumably this only refers to glare due to intrinsic brilliancy. Yet although the method might be an interesting weapon in the hands of an investigator with time and skill at his command, it probably is not a very readily applicable test.

After-images seem to depend so much on the state of the retina before the impression is received and on the conditions under which the images were observed. Prof. G. J. Burch§ has found that on retiring into a dark room confused after-images of ordinary objects are visible for as long as two hours, while in cases of exceptional dazzle even a longer period may be necessary for complete recovery.

Mr. W. R. Cooper disagreed with most of the definitions given during the discussion. If the illumination exceeded a certain value (corresponding to the greatest contraction of the iris), there was a feeling of discomfort, irrespective of any contrasts, as, for instance, on chalk roads in the brightest sunshine, more particularly on the Continent. But below this limiting value, glare was also possible, and it was this kind of glare that was important and was of daily occurrence. He thought it was due to contrast and to the eye attempting to adapt itself to two rather widely differing values of brightness at the same time. Thus, a lamp against a black background gave a greater sense of glare than the same lamp against a white wall. The general brightness in the case of the white wall was greater, more light being reflected; but the glare was greater in the case of the black wall, because the eye tried to adapt itself at the same time to the brilliancy of the lamp and to the darkness of the wall, which were widely different. The glowing filament of a metal filament lamp was too bright to be viewed with comfort at night, though not in the daytime. Anyone carrying a candle and entering a dark room instinctively put a hand between their eyes and the candle; the illumination was not increased by so doing, but the contrast was removed, and, consequently, the glare. Again, if one were reading by dull daylight and a lamp was turned on in the field of view, though not sufficiently near to give a good light, there would at once be a feeling of decreased illumination, although the illumination was really increased; this case, however, was perhaps complicated by other low-illumination effects. It would seem, therefore, that glare should be defined as a ratio, or something of that kind, expressing the ratio of the maximum to the minimum brightness within a certain area of the field of view. If this ratio was above a certain value, then there was "glare." Possibly the percentage decrease of the pupil in passing from the minimum to the maximum brightness might be taken as a measure of the glare; or it was just possible that a photographic plate might be used, the different densities being compared, or halation being used.

Turning to a more practical point, there was a great tendency at the present time to use sources of very high intrinsic brilliancy, such as metal filament lamps with clear globes. There was doubtless irradiation in such cases, but he doubted if the effect was as great as Mr. Trotter suggested. Such filaments in the field of view must have a very bad effect on the eyes, and they decreased the effectiveness of the illumi-

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* *The Illuminating Engineer*, London, Feb., 1910, p. 94.

† Schäfer's Physiology, vol. 2, p. 1078.

‡ *Illum. Eng.*, Lond., Feb., 1910, pp. 111, 115.

§ *Proc. Roy. Soc.*, London, 1905.

nation. Prof. Ashe in America had shown that the sensitiveness of the eye was diminished 30 per cent. if the source of light was visible even obliquely. It was, therefore, important in every way that sources of high intrinsic brilliancy should be properly shaded. Cases of bad illumination were only too frequent in public buildings, and the Society would do excellent work in such cases if it could bring pressure upon the authorities concerned to give hygienic illumination.

In Query 3 a distinction should be drawn between brilliancy and intrinsic brilliancy, the latter being the important quantity.

Mr. W. M. Mordey said that it was necessary to consider the relative subjective effects of different systems of lighting and their value for revealing objects to the eye, rather than the actual intensity of illumination. A room illuminated by reflected light produced an impression of restfulness even though it might appear less brightly illuminated than one in which by sources placed within the angle of vision were used. He questioned whether it was necessary to go so far as to say that all exposed lamps should be avoided, but the sharp contrast of such sources with dark surroundings was certainly objectionable the "whiplash" of the light from lamps so placed irritated the eyes and the nerves.

The Council of the Institution of Electrical Engineers had recently been giving a considerable amount of consideration to the illumination of their new home, and were resolved at all costs to avoid objectionable lighting of the character mentioned above. There was a great field open to makers of fixtures in the devising of methods of distributing the light from the standpoint of comfort rather than mere brilliancy.

In conclusion Mr. Mordey referred to the effects of snow-glare in mountainous regions, which were believed to be due to ultra-violet light. He had recently been interested in the use of the "Euphos" glasses, which were claimed to absorb such radiation and thus to protect the eyes. It would be interesting to know how far the quality of light reflected from snow and ice under such conditions had been examined spectroscopically.

Mr. Haydn Harrison did not think anybody had quite defined what glare was. Intrinsic brilliancy undoubtedly entered into the question, but contrast also came in, and they should be able to put it into an equation. Of course, if a brilliant source of light was adjacent to a reflecting surface illuminated up to and having the same intrinsic brilliancy as the source itself, the contrast would be unity and there would be no glare. Therefore it was a question of intrinsic brilliancy and contrast, and he thought it could be put into a formula which would be quite useful. If they held a lamp in front of a white screen and then in front of a black screen, the effect of glare in front of the white screen was negligible, In front of the black screen, however, it would be very high indeed. This showed that the factor of surroundings, given say in candle-feet on a white surface, must enter into the factor of glare and this would probably bring the whole question down to a mathematical possibility. This was particularly noticeable in street lighting, the effect of glare being absolutely lost if lamps were placed adjacent to white shades or reflectors with no intervening dark space. Yet the illumination might remain the same and had not been improved, although to the people using the street a great improvement was noticeable. Another point was that many people thought that if they could eliminate from view the source of light altogether and give indirect illumination they were arriving at a sort of millenium of illumination. But he did not think a shadowless room was any more pleasant to sit in than a shadowless life was to exist in. Shadows were natural factors and were necessary to bring a little definition into the illumination.

Mr. V. H. Mackinney expressed his interest in the various methods adopted for avoiding glare from artificial illuminants. He exhibited a glass diffusing globe designed on the lines suggested by Prof. Blondel in the early nineties. The external horizontal ribs, he ex-

plained, differed from all other forms in their profile; each rib was a combination of two independent sections, one *refracting*, the other *reflecting*, arranged so as to suppress all acute angles. They were calculated according to the law decided on for vertical distribution. With this combination a very good diffusion of light could be obtained over a considerable angle without any appreciable loss; the globes themselves appeared to be luminous all over and it was on this account that the inventors had given them the name of Holophane (ολος, entirely; φαινω, to shine). The average profile of the internal vertical ribs was intended to ensure horizontal diffusion.

Mr. Mackinney added that many light-sources when placed within the direct range of vision might be considered offensively bright, and that anything really disagreeable to the eye could not be considered artistic; consequently from the artistic standpoint a limit should be placed on the brightness of illuminants. He pointed out that light diffusers of the Holophane type are serviceable not only as a means of toning down the intrinsic brilliancy of the source to the proper limit, but also of re-distributing the light where it is most wanted while eliminating the high absorption losses of the ordinary shade.

Mr. Mackinney also explained that some years ago he had suggested a method for the avoidance of glare from the headlights of vehicles, &c. The main object had been to prevent the beam of light from rising more than 3 ft. 6 ins. above the road level. To attain this result use was made of a sphero-cylindrical lens system suitably decentred in its chief meridian. This arrangement, too, had the effect of throwing the light more normally on to the road surface, and the design could be arranged to cover any width of roadway at a specified distance away.

Turning to the physiological aspects of the subject, Mr. Mackinney said that it seemed to him that quite a large percentage of people were under the impression that the more recent intense illuminants were fatiguing to the eyes, and that light sources, when placed without shades at a distance of 10 ft. or less from the floor-level, were the direct cause of much of the prevalent eye trouble. He thought that "asthenopia," a symptom of fatigue often referred to by opticians as "eye strain" or "weak-sight," was sometimes brought about by prolonged work under a glaring system of lighting, and in many cases increased in such circumstances. Besides the accommodative, muscular, and iritic forms of asthenopia known to the optician, there were the conditions of retinal and reflex asthenopia for which "glare" would seem to be so directly responsible. These two latter forms came directly within the province of the oculist, and Mr. Mackinney expressed the wish that if a committe was appointed to deal further with the subject, this possibility of a glaring system giving rise to some form of asthenopia should not be lost sight of.

Again, if only on account of its effects on visual acuteness, excessive brilliancy was to be avoided. It was well known that form-acuity depended upon the amount of light received by the eye. This point was of considerable interest to opticians and others, for the reason that it indicated the advisability of a certain minimum illumination of test-types for subjective sight-testing. He himself had met with and described a case which seemed to suggest that a value of at least 30 metre-candles was desirable. He had not determined the point at which form acuity diminished owing to excessive brilliancy, but thought that it was within practical limits.

Mr. L. Gaster said that there could be no doubt of the immense importance of the question of "Glare" from the practical standpoint. They had heard a great number of different definitions of "Glare" and it was perhaps, only natural that there should be much difference of opinion since it was recognised that glare might be due to a variety of causes.

It had been pointed out that intrinsic brilliancy was the primary cause, but excessive contrast was also an important item, and the position of lights, quite

apart from their intrinsic brilliancy was also an important factor in causing "glare." As Dr. Kerr had pointed out in the previous discussions, even an only moderately brightly illuminated surface could give rise to the impression of glare if the rays from it came to the observer in the wrong direction. In the same way we had also to bear in mind the possibility of glare owing to the reflected light from shiny surfaces, from highly-glazed papers, for example. This was a matter which should receive the close attention of school authorities.

About 25 years ago, when electric light had been newly introduced, a well-known oculist, who was adviser to a large banking firm, had received complaints that all the employees were suffering from fatigue of the eyes. Investigations showed that this was due simply to the fact that the light was placed in the direct line of vision, so that instead of assisting the reader it absolutely hindered him. By immediately changing the position of the lamps, the matter was remedied.

He thought there were many banking and other city offices in which the same might be said to-day, and in which such attention was much needed.

He quite agreed with Mr. Cooper that it was desirable to draw attention to cases in which the lighting arrangements were obviously deficient. He had pointed out previously, that the illumination of the reading tables at the Patent Office Library was very unsatisfactory, and he was glad to see that steps had been taken to improve matters to some extent.

Turning next to the conditions of illumination in the streets, he would like to point out that the City authorities had insisted on the screening of sources of undesirably high intrinsic brilliancy placed at a low level, and that those who had participated in this discussion had almost invariably insisted upon the harm that was done by some of the existing methods of shop lighting, particularly the exposure of very powerful naked lamps outside the windows. He strongly approved of the action of the City authorities in framing regulations that such lights should be screened, and he hoped that such regulations would be strictly enforced. He was also glad to see that the London County Council contemplated the framing of recommendations to shop-keepers advising that sources of light should not be placed among the contents of their windows. This was not only desirable from the standpoint of avoiding risk of fire, but also because the use of sources in this way was bad illuminating engineering, and disastrous to the eyes of those looking into the windows. In this case, the correct motto was "*Light on the object, not in the eye.*"

Taking a wide view of the contributions to these discussions, he thought there was a general concensus of opinion that something should be done to limit the possibility of glare from the new and intensely bright illuminants, though some difference of opinion might exist as to the best way of achieving this end. All, however, condemned the placing of such sources so that the rays could stream directly into the eyes. It was also worth noting, that there was a degree of unanimity as to the permissible maximum of intrinsic brilliancy of sources to be used in dwelling-rooms. The figures of Stockhausen, Dr. Louis Bell, Professor Weber, and Mr. Trotter agreed very closely, although, in the first three cases, obtained by quite different methods. However, it must, of course, be recognised that there were naturally still many facts to be made clear. He would, therefore, like to bring before the meeting the suggestion of Dr. Stockhausen, and he submitted it in the form of the following resolution :—

"That an international Committee representative of the different professions interested in illumination be appointed by the Illuminating Engineering Society to consider the question of 'Glare' from modern illuminants, to collect evidence as to its nature, causes, and effects, and to frame recommendations as to how its injurious effects can be avoided. That the Editing Committee of the Illuminating Engineering Society should deal with the question, approach the necessary authorities,

and take due steps for the formation of such committee."

The President then explained that this resolution was being considered by the Council and that the necessary steps would be taken.

Dr. W. H. Ettles suggested that some agreement should be come to regarding the physiological questions involved before they went any further.

Mr. Nash, referring to Mr. Trotter's remark concerning the increased diameter of a luminous filament as compared with the known actual diameter, suggested that this might be due to vibration.

Mr. Haydn T. Harrison said that another theory was that as we momentarily look at a filament burning brightly, our eyes fill with moisture, and this absolutely put the whole of the filament out of view at once.

Dr. F. W. Edridge Green said some people were very slow in getting adapted to a light. He found in experiments in mixing colours that as he reduced the illumination some people would hardly be able to see the mixture at all, whilst it was perfectly visible to others. Similarly one person would take much longer than another in getting used to the light of a room where the illumination happened to be very poor, or it was nearly dark. In fact, there was one particular kind of person—it was a congenital complaint—who always suffered from glare and who had a very slow adaptation in getting used to even an ordinary light. The effect of light on surrounding parts could be clearly demonstrated by the Helmholtz experiment of the candle in a dark doorway.

The President, in winding up the discussion, said he did not believe the apparent increase in the size of a filament when glowing was due to vibration. This was borne out by throwing the image of a filament on a screen, when no vibration was discernable. The apparent enlargement was certainly due to something in the eye. It had been called irradiation. What was irradiation ? It included a good many things, the two principal ones being the actual spreading in the retina—which might be photo-chemical—and also to the spherical aberration of the eye and the imperfection of the lens apparatus. It was bad focussing, in fact, which largely caused irradiation.

He agreed with Mr. Trotter that intrinsic brilliancy must be interpreted by dividing the total candle-power not by the actual emitting area but by the apparent emitting area. But this did not by any means bring them to the end of the subject, for as a number of speakers had pointed out, the question of contrast was an important one in relation to backgrounds. He would like further experiments to be tried in this connection. He wished there were some means of producing over a definite area a definite degree of intrinsic brilliancy and multiplying it indefinitely. If they took a square inch having one candle-power uniformly spread over it, and viewed it from a distance of one foot, the image of this, if the eye were perfect, would be a little bright square patch on the retina at the back. If they could have this, first against a black background, and then surround it by eight other square inches equally illuminated, should they be able to decide whether the middle square inch would seem to be exactly as brilliant as it was before ?

Or this could be tried. One square inch, one foot away, illuminated; replace this by nine square inches three feet away. Geometrically this gave an image of the same size; would they find equal glare in the two cases ? Geometrically they ought to, but he was not at all sure that they would, find it so physiologically.

He did not think the effect of stray light coming into the eye could be called glare. In his own case he was aware that the visual medium of his eyes was becoming turbid, and any side light entering the cornea created a kind of hazy illumination all over. He was looking through a slightly illuminated hazy medium, and therefore it affected his ability to distinguish black or white under an imperfect illumination. He was perfectly certain that he actually saw more haze round a naked light than he used to, but he did not call it glare. He

should be sorry to accept Mr. Baugh's conclusion that glare only existed when we saw an after-image, as after-images were produced with very low illuminants indeed, and were then certainly not the result of glare. In the discussion, the suggestion of Dr. Stockhausen as to the formation of an international committee was a very valuable one. It was a suggestion which should bear fruit, for more data was wanted. No doubt the Council would be encouraged to take action upon this matter, and also upon the suggestion of Dr. Ettles that a discussion should be organised upon pure "light sensation" uncomplicated by colour and other issues. Both these matters would be referred to the Council.

Glare, its Causes and Effects.

Communications from Corresponding Members.

Dr. K. Stockhausen, Dresden.

(*Continued from p.* 116.)

Query 2.—The necessity of devising methods of protecting the eyes from the possibility of absolute "Glare" is a matter which must appeal to and be studied by the illuminating engineer. On the other hand it is probable that the engineer does not get much opportunity of observing the effects experienced by those who suffer from glare of this kind; people who suffer in this way usually seek the advice of the oculist, and it is to this expert that we must turn for evidence of such cases. It is true that one finds in medical literature many cases described in which the high intrinsic brilliancy of sources of light, their arrangement, or the quality of radiation which they furnish, have apparently given rise to injuries to eyesight. Yet it must be admitted that oculists themselves often betray considerable uncertainty as to the comparative effects of different qualities of light on the eye, and even regarding the nature of "glare" itself. Thus it comes about that we often notice an injury to eyesight attributed by one expert to quite a different cause from that which another oculist might diagnose, and with the same conditions of illumination.

A further cause of uncertainty, is the lack of knowledge of oculists regarding the technicalities of illumination. Therefore the harmonious co-operation of the illuminating engineer, and the oculist would be in the interests of both professions, in order to obtain data of mutual value.

Realizing, as I do, the difficulty of obtaining really reliable data as to the effects of different systems of illumination, and the necessity of forming some more definite conclusions as to the principles which ought to guide us in selecting methods of illumination, from the hygienic aspect, I should like to make the following proposal. Let the Illuminating Engineering Society send to the Opthalmological Societies in all countries a request to keep them informed of all cases of injury to eyesight which are apparently due to the effect of some unsatisfactory system of illumination. In addition, it would be a good plan for engineers who are interested in this question of illumination, to enter into communication with well-known oculists, and to co-operate with them in collecting such cases, adding their technical knowledge of the conditions in which the defects of eyesight referred to arose. The material should be assembled in each country, its authenticity tested, and the results forwarded to a central body, the Illuminating Engineers Society, who would again set aside cases of doubtful authenticity, and thoroughly sift the whole material. A report should then be published each year.

This would be a grateful task for the Illuminating Engineering Society to undertake, and the result would not only be of interest from the purely hygienic standpoint, but would also enable engineers to collect data regarding the effects of different kinds of

lamps (electrical, acetelyne, high-pressure gas, &c.), the consumption of gas or electricity, candle-power, intensity of illumination required for different purposes, and other useful data, all of which information would be of practical value to engineers. The enquiries referred to, would preferably be circulated in several different languages.

In exactly the same way, it might be recommended that a valuable collection of facts, would be obtained by making inquiries regarding the arrangements existing in schools, lecture halls, theatres, &c. In this case, however, the inquiries should be addressed to medical men responsible for the inspection of schools, and teachers who, it might naturally be expected, would be keenly interested in such questions.

The illumination of such places by daylight conditions should also receive special attention ; most of us have met with cases in which the system of artificial illumination has borne the brunt of blame, which should really have been laid upon the bad daylight arrangements. In addition, it is, of course, desirable that illuminating engineers should make a practice of interesting themselves not only in the particular system of light with which they are concerned, but also in the proper application of daylight.

Queries 3 *and* 10.—Are we in a position to lay down definite recommendations regarding the practical arrangement, from the hygienic standpoint, of sources of light ? This question can undoubtedly be answered in the affirmative. We have to consider not only those factors which may lead to direct injury to sight, but also those which may give rise to more gradual effects such as fatigue. Moreover, it is rarely sufficiently realized that fatigue of the eye carries with it an injurious influence on the whole organism.

There is also no doubt that the intrinsic brilliancy of modern illuminants is undesirably high, and that this may give rise to severe dazzle ; we ought, therefore, to avoid the use of such sources, as possess a higher intrinsic brilliancy than 0·75 H.K. per sq. cm. in an unscreened condition, especially in interiors. At the very least we ought to place such sources high up on the ceiling out of the direct range of view, so as to eliminate thepossibility of their images being formed on the retina.

Yet this last method can only be regarded as a half-step, and is not a complete solution of the problem. The only satisfactory method of avoiding glare is to surround all sources with suitable diffusing surfaces, such as opal and frosted globes, so as to reduce their intrinsic brilliancy below the permissible value. By the use of such shades we can cut down the surface-brightness to any desired value. Unfortunately, however, many of the globes used in practice are not satisfactory either from the hygienic or the æsthetic standpoint. My own experiments have proved that there are only few globes in use which really cut down the intrinsic brilliancy of the sources for which they are intended to 0·75 K.H. per sq. cm. Most of them exhibit too high an intrinsic brilliancy at the centre and much too low a value over the outside portions. From the artistic standpoint the effect is often the reverse of pleasing. A uniformly illuminated globe, on the other hand, has usually a very satisfactory æsthetic effect. As an illustration of such uniformity, I may mention the opal glass globe adopted with the quartz tube mercury vapour lamp.

In most cases it is difficult to secure such uniform illumination without at the same time absorbing too much light. A very satisfactory effect indeed can be secured by using a small globe of prismatic glass designed to distribute the light uniformly in all directions, (such as the Holophane), and over this a larger globe made of only slightly obscured opal glass ; by this means perfect uniformity coupled with only a comparatively slight loss of light can be secured. Moreover, the perfect distribution of light achieved by the inner globe means that the intrinsic brilliancy of the whole is low. This second globe gives a very pleasing effect when it is frosted with a "silky-matt" surface such as has

recently been devised by Messrs. Putzler (Schlesien). The use of the "Euphos" glass manufactured by the same firm is also beneficial. We have seen that the ultra-violet rays are, to an especial degree, responsible for fatigue of the eye. Such rays are completely absorbed by the yellow-green "Euphos" glass. It is therefore advantageous to make chimneys, electric lamp-bulbs, &c., from glass of this nature.

Query 6.—We have seen that the intrinsic brilliancy of the source of light is the most potent factor in producing glare. The measurement of intrinsic brilliancy is, therefore, a very important matter. This quality depends upon two items, the actual intensity of the source, and its superficial area. The intensity in a horizontal direction is usually obtained by ordinary photometrical means. It would, however, be indisputably more correct to determine the mean sperical candle-power, and so to avoid those sources of uncertainty which are always connected with measurements in horizontal directions.

One should, therefore, distinguish carefully between "horizontal" and spherical intrinsic brilliancy.

By horizontal intrinsic brilliancy, we should understand the surface-brightness of the source in a horizontal plane drawn through the centre of radiation of this source. On the other hand, by "spherical intrinsic brilliancy" we should understand the surface brightness which would be obtained by dividing the total flux of light in all directions by the total spherical area of the surface over which it is distributed. It is thus that intrinsic brilliancy which would actually exist if the same total amount of light were produced, but distributed uniformly in all directions.

As a rule we obtain by measurement the horizontal intrinsic brilliancy values which are considerably greater than the spherical value, while the spherical intrinsic brilliancy of incandescent filament and indeed in the case of all illuminating bodies which possess uniformly bright radiating surfaces, is identical with their actual intrinsic brilliancy in any direction.

The spherical area of a source is best measured by photographical means, *i.e.*, by obtaining photographs of the source in a given direction and taking into account the magnification or reduction so occasioned. The area of the projected image is obtained by the means of the planimeter. In the case of glow-lamps it is only possible to obtain the length of the filament with sufficient exactitude by this means. The diameter in such cases must be obtained with the microscope. In general a determination of intrinsic brilliancy can be made, in my experience, with an accuracy of 2 to 3 per cent.

Query 7.—So far we have seen that both the visible and the invisible radiation from an illuminant may have physiological effects, and may contribute to cause glare. It remains to determine what part, exactly, is played by each of these varieties. Most observers have come to the conclusion that the infra-red rays are bad in this respect, but that the ultra-violet rays are even more so. It would appear that the movements of the pigment in the eye are retarded or even prevented by the heating effect of the former rays. Now pigment-wandering, like the pupil-contraction, constitutes a serviceable protection against glare. It has therefore been suggested that the newer illuminants, such as the metallic filament lamps, constitute an important advance from the hygienic standpoint, because the proportion of red and infra-red rays in such sources is less than was the case in the older sources of light.

The yellow-green, green, and blue rays must be regarded as the kind of radiation most favourable to the eye from the hygienic standpoint. In the case of these rays both means of protection against glare, the contraction of the pupil and the wandering of the pigment, are most effective. In addition the circumstances that the visual acuity of the eye, and its greatest sensitiveness to light, are normally in the neighbourhood of the yellow-green,

seem to suggest that this is the region of the spectrum to which the human eye is best adapted.

The violet and ultra-violet rays up to 375 $\mu\mu$ must be regarded as to some extent injurious, partly because their chemical action may be prejudicial to the retina of the eye, and partly because they give rise to fluorescence of the eye-lens, and therefore prejudice acuteness of vision, owing to the blurring of the retinal images; they also add to the dazzling effects of excess of visible light.*

The ultra-violet rays from 375 $\mu\mu$ to 320 $\mu\mu$ only contribute slightly to fluorescence of the lens, being very strongly absorbed thereby; only in the case of young people up to the age of twenty-five years are they able to reach the retina, and even then are very much weakened in so doing. Nevertheless it is very desirable to guard the eyes of all children in schools and young students, from rays of this kind.

Ultra-violet rays having a wave-length of less than 320 $\mu\mu$ cannot penetrate to the retina, and are mainly responsible for inflammation of the outer eye.

In order to summarize completely the influence of ultra-violet light on the eye, we must not forget one suggestion, which, it is true, has not yet been demonstrated with certainty, but the probability of which is strongly supported by the most recent researches. Several experimenters have put forward the suggestion, as the result of their researches, that the cataract of old age is the direct effect of the rays of light striking the eye, and especially the ultra-violet rays. Dr. Schanz and the writer, as the result of their experiments, are also inclined to support this suggestion.

The cataract characteristic of old age shows itself in the development of a more or less marked turbidity or yellow colouration of the eye-lens which, as time goes on, becomes less and less transparent. Now the ultra-violet rays between 375 $\mu\mu$ to 320 $\mu\mu$ are strongly absorbed by the eye-lens and those between 400 $\mu\mu$ and 375 $\mu\mu$ are for the most part altered into fluorescence light in the lens; violet rays also, as Schanz and Stockhausen have shown, generally contribute to some extent to this change.

Now in general it is only those rays which are absorbed by the substances which exert a chemical action upon it, and we are therefore justified in supposing that it is the ultra-violet rays, which are absorbed by the lens, that produce the effect referred to above. In addition, the conversion of all ultra-violet rays and a portion of violet light into visible light by fluorescence indicates a transformation of energy and in the course of years may produce the injury to the eye known as cataract.

This explanation of the origin of cataract has been supported by several recent experiments. For example, Handmann has published an exhaustive work in which, as the result of observations and research extended over many years, he has established the fact that cataract in the majority of cases begins in the lower half of the eye-lens; he suggests that this is partially due to the fact that the physically active rays from artificial and daylight illumination are usually free to reach the lower parts of the eye, while the eye-lid protects the upper portion.

In addition, Schanz and Stockhausen in a recent work* come to the conclusion that the variety of cataract occurring among glass workers is due to the action of rays of short wave length; for the light which is radiated from glass ovens and incandescent masses of glass, does not contain those rays which inflame the outer eye, but only those which are mainly detrimental to the eye-lens.

Hess, in his experiments on the yellow colouration of the eye-lens attributes this gradual change to the absorption of ultra-violet rays, and also, as time goes on, an increasing

* Schanz and Stockhausen have studied the fluorescence of the human eye-lens by the method of crossed spectra, and have shown that the light due to this fluorescence contains all the rays in the visible spectrum; red, yellow, and violet, however, are only weakly present, green are the most prominent, and blue apparently somewhat less in intensity than the green. This work has been for some time in the hands of the printer.

* Über die Aetologie des Glasmacherstars.

percentage of violet light as well. He therefore points to the probability that it is these rays which are mainly instrumental in causing such defects of the eye as gradually appear in old age and the accompanying loss in acuteness of vision.

The injuries to the eye mentioned above and others known to the medical authorities into which I need not enter on the present occasion, are due mainly to the gradual influence of ultra-violet light on comparatively long wave-length such as 400 $\mu\mu$ to 320 $\mu\mu$. Other effects, however, such as *opthalmia electria* and acute inflammation generally, are mainly caused by the ultra-violet rays of wavelength less than 320 $\mu\mu$. Such inflammations, which are attended with great inconvenience and pain, in some cases disappear in a few days without leaving permanent injury behind, in other cases they leave permanent defects. To surround sources of light with globes of ordinary glass certainly helps to reduce the possibility of inflammation of this kind, but it does not prevent it entirely. For ordinary glass, in the usual thickness, allows ultra-violet rays between 400 $\mu\mu$ and 300 $\mu\mu$ to pass unhindered.

As one of the physical aims in the production of light we may therefore state the following recommendation, namely that *we should try to produce sources which are weak in heat rays and ultra-violet rays, but rich in radiation of a greenish yellow, green, and blue variety.*

It is naturally difficult to secure radiation of this kind by modifying the qualities of the illumination itself; it is much easier to surround them with suitable globes which absorb or weaken the objectionable radiation. Ordinary varieties of glass, however, fulfill this condition only very imperfectly, and the author was therefore led to the production of the "Euphos" glass, which has the property of absorbing the ultra-violet rays, and also, to some degree, those in the red and infra-red, and yet allows the greenish yellow, green, and blue to pass through almost unaffected.

Queries 8 *to* 9.—As an example of one branch of the subject of illuminating engineering in which hygienic recommendations are almost invariably ignored, we may quote the case of modern street lighting. The sources of light, as ordinarily used, high-pressure incandescent gas light, and electric arc lamps especially, have all so strong an intrinsic brilliancy that the eye suffers "absolute" and permanent dazzling in encountering them. In addition, the extremely foolish system of shop-window lighting by powerful lights placed within the range of vision of pedestrians helps to produce an impression of glare, and cannot be too strongly censured. The natural result is that pedestrians are dazzled and bewildered, and their movements amid the traffic become uncertain. In addition to the strictly "glaring" effect the high intrinsic brilliancy of these sources causes a marked contraction of the pupil of the aperture of the eye and the total flux of light, entering the eye, is reduced as the result. Now this has exactly the same effect as if the general lighting of the street, that is, the light received by reflection from illuminated bodies, had been enormously reduced. For the great part of such reflected light is kept out of the eye by contraction of the pupil, and is absolutely lost. Thus modern methods of street lighting often involve the expenditure of light in a quite useless manner, and so far from facilitating the safe regulation of traffic, actually hinder it. These objections can only be met by the reduction in the intrinsic brilliancy of street lamps by the use of suitably designed screens and globes. The polar curve of light distribution of many sources can be very materially altered by the use of diffusion, refraction, and reflexion, without too serious a loss of light being experienced. By the application of these principles the expenditure of light in the wrong direction could be avoided and the conditions from the standpoint of traffic much improved.

The needs of traffic are also often ill-served by head-lights of many cabs, automobiles, &c., and the sharply confined beam of light which they are

inclined to cast into the eyes of passers-by.

In many cases lanterns attached to vehicles might be profitably provided with diffusing glass screens, and the source itself provided with a small prismatic globe so as to produce a more uniformly illuminated body. In addition the provision of a small general illumination of the whole vehicle would serve to minimise the tendency towards an unpleasantly glaring effect. Very frequently under the present conditions we see these brilliant headlights in dark or weakly illuminated streets amidst sombre surroundings. The vehicle itself appears a dark mass owing to the great brilliancy of the light in front of it. If, however, a portion of the light was used to illuminate the vehicle, we should have a better opportunity of observing its nature and the intrinsic brilliancy of the lantern itself would not be so severely felt.

Probably illuminated signs, periodically shining advertising devices, and so forth, being composed mainly of frosted lamps, are not, as a rule answerable for a great degree of glare, and in addition, the light from these signs helps to illuminate the surroundings so that the contrast is not so severe. When, however, unscreened and naked lamps are used for this purpose, the effects are naturally often objectionable.

Query 11.—A complete answer to this question would not be very serviceable unless accompanied by illustrations and examples which would make this communication too lengthy. I will therefore confine myself to a few short remarks on the subject of shop lighting. It cannot be sufficiently insisted upon, that the illumination of display windows by means of unscreened powerful sources, placed outside and at a low level, or by the use of such sources placed among the goods themselves, so as to fall within the direct range of vision of the observer, is most unsatisfactory. When such methods are employed it is impossible to avoid glare.

On the other hand, the method of illuminating show-windows by diffused light deserves recommendation. According to this system the lamps are placed on the ceiling of the shop window above prismatic or frosted glass panels. The light is thus shed upon the goods below, while the passer by cannot see the actual source. The danger of dazzling pedestrians can also be avoided by the method of screening the lamps by opaque reflectors which throw light on the goods and at the same time conceal the sources from those looking into the windows.

CONCLUSIONS.

I feel that in taking up such a timely question as the subject of glare, the Illuminating Engineering Society is undertaking a very useful and valuable work, and feel sure that the discussion will give rise to a number of profitable suggestions. It would, however, appear to me to be a pity if these proposals for the restriction of glare were merely to be the subject of scientific discussion, and to be subsequently published as such without the general public obtaining the full benefit of such recommendations as can be made.

In this matter both the physiological and physical aspects are of the very greatest importance.

We have seen how closely connected with physiology any examination into the cause of glare must be.

In the same way we must not forget the physical aspects of illumination,' which include methods of measurement, exact definition, and the standardising conditions affecting intensity of light, which are often completely absent in physiological literature. An attempt to bring together these aspects, such as that of the Illuminating Engineering Society, seems to me a great step forward.

I should, therefore, like to make the further proposal that The Illuminating Engineering Society should appoint an International Commission on the subject, consisting of about 8 or 10 authorities in different countries who should include among their number at least two experts on the physiological and opthalmological aspects of "glare," and who should, in addition, have a special knowledge of, and interest in illumination. It would be the work of this committee to promote scientific

nomenclature and to frame recommendations relating to glare and to give them full publicity.

Among the questions which such a committee might profitably take up, I may suggest the following :—

1. The Definition of Glare.
2. The Definition of Intrinsic Brilliancy or Surface-Brightness.
3. Proposals for Measurement of the Range of Adaptation to lights of varying brilliancy possessed by the Retina of the Human Eye (see *Illuminating Engineer*, Feb., 1910, page 110).
4. Proposals for Methods of Measuring the Degree of Glare of illuminants.
5. Investigations on the question whether or no the Study of "After-Images" could form the basis of such a test.
6. A Proposal for the Quantitive Measurement of Ultra Violet Light.
7. The establishment of the Maximum Physiologically Permissible Intrinsic Brilliancy.
8. Rules for the Illumination of School Rooms, Lecture Theatres, &c.
9. Rules for Street and Shop Window Illumination.

Dr. H. Lux (Berlin) : I should like to deal with the query of the Illuminating Engineering Society on the subject of measurement of glare, and the instruments that can be used for the purpose.

The glare or "intrinsic brilliancy" of a surface is defined by the formula, $\frac{J.}{s. \cos \epsilon}$ where J. is the intensity of the light, s. is the area of the illuminating surface, and ϵ the angle of inclination of the surface to the eye.

The difficulties in the measurement of intrinsic brilliancy are mainly connected with the measurement of the surface, and the methods hitherto proposed for determining this factor do not seem to me satisfactory. Dr. Krüss suggests that the area of such surfaces can be adequately estimated by the aid of his flame-measuring apparatus. Dr. Stockhausen, on the other hand, photographs the radiating surface and allowing for the magnification of the image, determines the area of the image by means of the planimeter.

I believe, however, that the error in the determination by these methods would be very considerable in the case of such radiating surfaces as incandescent filaments or mantles, &c.

I have previously made experiments with the method of photography, involving the subsequent measurement of the area of the image with a planimeter, for other purposes, and am convinced that the error in the results may amount to as much as 30 per cent, because the edges of the image are not sufficiently sharp. By the use of the Krüss flame-measurer even greater errors may result.

On this ground it seems to me preferable to determine intrinsic brilliancy by purely optical methods involving merely the selection of a certain area of the luminous surface, by the use of a diaphram with a suitable aperture in it, &c., which can be measured with certitude.

When such an aperture is completely filled by the bright surface behind it the plane of the aperture itself can be regarded as the position of the source of the light and its intensity can be easily determined by the usual photometrical methods. The area being exactly known, the intrinsic brilliancy can thus easily be obtained by a single measurement.

The application of this method presents no difficulty when we have to deal with a primary illuminating surface of considerable dimensions, for example, open flames and electric arcs, &c. The determination of intrinsic brilliancy of incandescent filaments and mantels is, however, more difficult, since in this case the area of the aperture in front of the incandescent surface may naturally have to be very small.

Even in this case, however, it is possible to over-come this difficulty by means of the apparatus which I am about to describe :—

This arrangement involves a sector

device essentially similar to that devised by Brodhun in which, however, it is the beam of light which is caused to rotate by optical means. By means of a small motor m a pair of rotating Fresnel prisms are caused to rotate so that the beams of light, in revolving, traces out a cylinder, and is then concentrated along the axis of

Fresnel prisms there is on one side a second box, l, which contains the comparison light.

Between the comparison light and the sector arrangements there is an adjustable screen r, which contains dark glasses of varying opacities. On this side of the sector there is a Bechstein photometer provided with an

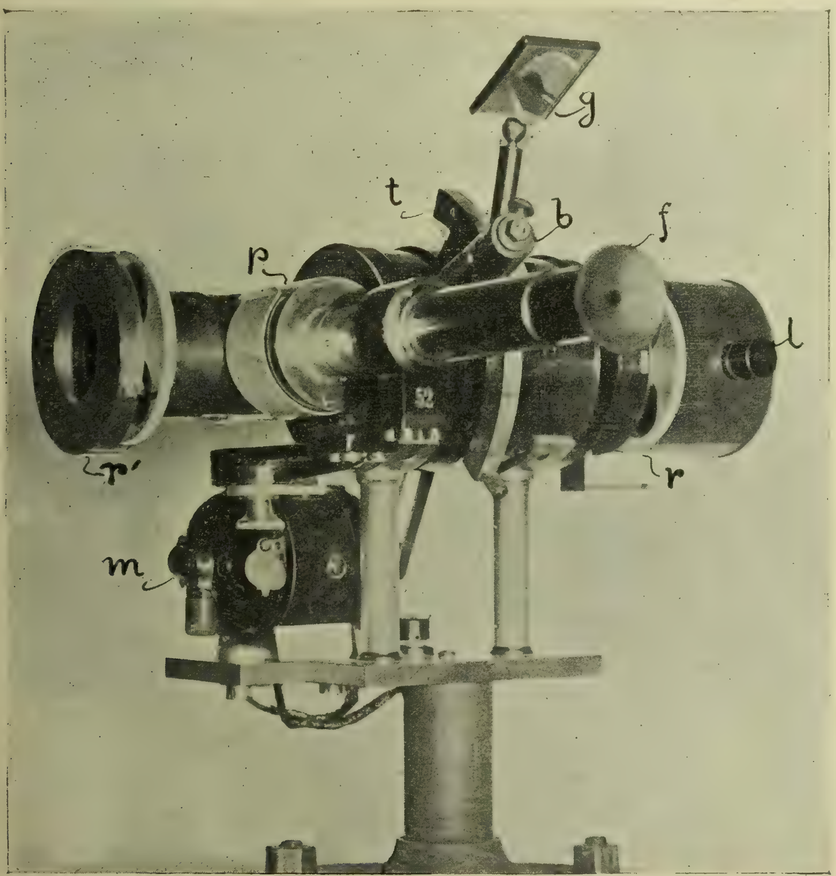

Fig. 1.

this cylinder. During their rotation the bundle of rays traverse a stationary screen with an adjustable sector aperture, and by altering this sector (the width of which is read on the scale T.), the extent of the aperture and the intensity of the light can be increased or reduced in any desired proportion.

Attached to the box containing the sector arrangements of the rotating

observation telescope f. On the opposite side of the photometer, which is directed towards the lamp to be tested, there is another disc r', also provided with a series of dark glasses (see Fig. 1). In order to serve for the determination of "glare," the disc r' can be replaced by a fine slit, similar to that used in the spectroscope (see Fig. 2).

The slit s is 5 millimetres in length,

and its breadth can be read on a drum *n* in hundredths of millimetres. Immediately behind the slit there is a frosted glass screen of known transparency. The slit is open just sufficiently wide to be covered entirely by the illuminating source, of which the intrinsic brilliancy is to be determined. The intensity of the illuminated slit on. Meantime I may add, that by their aid I have already ascertained that even the intrinsic brilliancy of the extremely thin filament of a 32-candle-power 22-volt Tungsten lamp can be measured by this photometric means, although the area of the slit used in this case is only about 0·25 square millimetres.

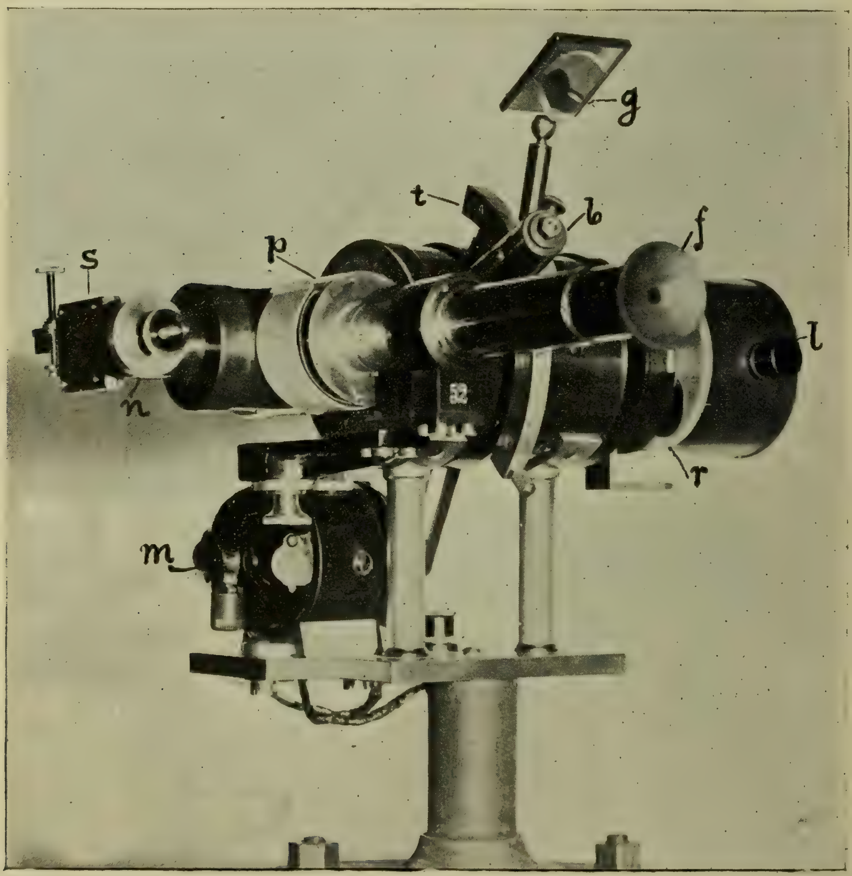

FIG. 2.

is then measured by the ordinary photometrical method, the light being adjusted by an alteration of the sector opening.

In this short space it is hardly possible for me to describe the series of exact measurements which I have been able to carry out with this recently devised apparatus; I hope, however, to describe these researches in greater detail later

Professor A. Grau (VIENNA): A source of light or illuminated surface must be termed "glaring" if either its intrinsic brilliancy is excessive or exceeds that of the surroundings to such an extent that the contrast between the image of the object formed on the retina and its surroundings is too severe.

As examples of glare so produced, we

may mention the result of gazing direct at a white-glowing surface of large area or a metallic filament glow lamp consuming one watt per Hefner, or, lastly, the effect of passing from more or less dark surroundings into a brightly illuminated room.

In many cases one can avoid the possibility of glare by the use of what may be termed "diffuse" or "inverted" illumination, but as a rule it seems to me very convenient to obtain the same result by sub-division, *i.e.*, the use of a larger number of small sources in preference to a few powerful ones.

As regards the effect of light from different regions of the spectrum, I may say that while it seems to be generally recognized that the rays of short wave-length are less satisfactory hygienically than those of long wave-length, I still do not think that the increased percentage of such radiation in the newer illuminants is the primary cause of "glare."

Messrs. Korting & Mathieson, BERLIN (*communicated by Mr. J. Eck*) :—Before dealing with the questions individually it is desirable to deal with natural and artificial illumination from a general standpoint.

The first natural source of illumination is the sun, and in this connection we must distinguish between two distinct sets of conditions :—

1. The direct illumination, such as is given by sunshine.
2. The indirect illumination, such as is given by a cloudy sky.

Between these two forms of illumination there is a considerable difference. In the first case, the direct light greatly preponderates as compared with the diffused light reflected from the dust particles in the air, and such reflection as is due to one or two clouds which may be present, the result being large shadow contrasts. In the second case we have a more perfect form of diffused light than can be obtained by any artificial means. Without doubt diffused daylight, on account of the evenly diffused shadowless illumination, is, for many operations, much superior to direct daylight.

Diffused daylight approaches very closely to even illumination, for there is no appreciable contrast of light and shadow, and most particularly no glaring effect on the eyes, due to the sun, are present.

Although evenly diffused daylight has its great advantages, there are many operations, which, although somewhat interfered with by the presence of shadows, can be carried on with equal advantage in direct sunlight.

In addition to this direct sunlight is desirable for some purposes, because of the contrasts or shadows it produces, and further, if the amount of heat radiated is not too great, it has an enlivening and stimulating effect, as we all realise by the popularity of outdoor sports, walking, running, playing games, &c. We are so accustomed to protect our eyes from the direct sunlight that we cannot in general say that sunshine has a deleterious effect, although it is undoubtedly the most glaring of all illumination, due to the fact that in intrinsic brilliancy and in area no source of artificial illumination has yet been able to compete with it.

It is desirable when arranging for the artificial illumination of places, to approach, as far as possible, both in quality and evenness of diffusion, the illumination obtained by day from the sun.

Dealing with the question of the quality of artificial illumination, it is desirable, especially for offices, workshops, factories, &c., to have illumination that is practically shadow-free, and this can be obtained in the most satisfactory manner by the means of arc lamps, either by having suitable diffusing and distributing globes, or through reflected light from large surfaces, used in connection with open arc lamps. These systems, without doubt, entail a certain amount of loss in light, but in spite of this, due to the absence of contrast, an illumination apparently equal to that obtained from the direct lighting open arc lamp is obtained. The requirements of rooms used for various operations are different, but these are well known to those interested in artificial illumination. During the last twenty years three chief systems of arc lamp illumination have become

recognised as suitable for interior illumination. The best system is that which is known as the totally indirect, viz., in which nearly the whole of the direct rays from the lamp are reflected from a matt white surface placed above the lamp, which for this purpose is constructed to burn with its crater inverted. Next in value to this, is that using the ordinary arc lamp, that is to say, without any inversion of the arc, but having below the arc an opal glass screen, which permits a certain proportion of the light to pass through, whilst the rest is reflected towards the ceiling, and there again reflected, this system may be distinguished as the Semi-Indirect.

The third system also uses the ordinary arc lamp in connection with either the usual opaline glass, a ground glass, or an opal glass globe : even with this style of lamp a considerable proportion of the light is reflected from the surroundings, either the ceiling or the walls, and mingles with the direct light, producing an inferior grade of semi-indirect illumination, still for the present purposes this may be called Direct Illumination.

The system of illumination, as mentioned above, that is desirable for different places, varies, but from practical experience we have found the following a good general rule :—

(*a*) Totally Indirect Light for lecture-rooms, school-rooms, drawing offices, museums, and indoor tennis courts.

(*b*) Semi-Indirect Light, chiefly for churches, libraries, operating-rooms, commercial offices, spinning and weaving mills, post offices, sorting-rooms, type-setting departments, printing offices woodworking mills, paper and rubber factories, gymnasiums, &c.

(*c*) Direct Lighting for showrooms, dancing and concert halls, restaurants and cafés, market places, slaughter houses, swimming baths, shops, railway works and generally speaking factories dealing with large articles, such as pumps, boilers, engines, castings, also for bleaching works, dye - mixing establishments, breweries, &c., and in general for undertakings which are conducted to a large extent in the open air.

In some cases, as, for instance, large public rooms used for concert and assembly purposes, a mixed system of lighting is often desirable, such as partly direct illumination and partly indirect illumination.

The above classification is purely general, and will often have to be modified in accordance with the size of the rooms, the taste of the owners, and other local circumstances.

Glare from Illumination.

The glare produced by a source of light is often due to direct reflection from the surfacce of the object, and this often interferes largely with the power of observation.

Every one has noticed that white writing on a black board is often illegible, due to reflection of the light from the smooth surface of the board, while the same effect is also noticeable in connection with black letters printed on a highly glazed white paper. Both of these effects may be said to be due to a form of glare, and it is well to remember that these effects are not present when indirect or diffused light is used. When the source of illumination is a small one, such as, for instance, an incandescent lamp, care must always be taken to place the observer and the object in such positions that no direct reflection from the object reaches the eye.

The Glaring Effects Produced from the Source of Illumination.

Glare can only be produced on the eye, when the source of illumination is within the radius of observation covered by the eye. It is, therefore, necessary to arrange all illumination-devices so that they are outside the ordinary radius of observation of the eye, that is to say, one should place them either high up, or if this is not possible, place some form of screen or shade in a suitable position. Most serious results can be produced by sources of illumination when the observer has to keep his attention for a considerable time upon a certain object or look for a

period in a certain direction, such as may be the case in schools and lecture rooms. For such purposes, all direct forms of illumination should be abolished, and only totally indirect ones used. In other cases, in offices, libraries, &c., where persons are chiefly looking in the downwards direction, it is permissible for the light to have a certain amount of direct reflection, and therefore here, the semi-indirect from of illumination is permissible.

Taking into consideration the above general statements, the following answers are given to the queries.

1. What exactly constitutes a "glaring" system of illumination ?

A brilliant form of illumination in which direct light falls upon the eyes from one direction and produces a tiring effect or eye-strain ; also, if an excessively brilliant source of illumination comes within the radius of observation of the eye, and so affects it that the power of observation is diminished.

2. Evidence is needed of instances in which undue brilliancy of injudiciously placed sources of light has been unquestionably projudicial to eyesight. Suggestions for the collection of data regarding eyesight and health and conditions of illumination enjoyed by school children, &c.

The reply given under 1 above, instances the prejudicial effects upon the eyes. As already mentioned, it is desirable to eliminate as far as possible, all light coming direct from the source into the eye. The cases given above in connection with lecture halls and schools are important, and it is well to remember that with artificial illumination, it is quite possible to arrange the source of light so that approximately the same illuminating effects are obtained in rooms at night as are present in daylight.

3. Is it desirable to recommend that sources of a brilliancy higher than a certain limiting value should never be used unscreened in interiors ? Or that such sources should always be placed at a certain minimum distance from the ground ?

This is dealt with in the general remarks preceding the definite replies.

4. What is the maximum intrinsic brilliancy on the part of an illuminant which can be considered physiologically harmless under ordinary conditions ? To what extent is the glaring effect of bright lights dependent on the distance of the eye, on "brightness per unit area," and on the area and total amount of light radiated by a source ? In what manner is the desirable intrinsic brilliancy of an illuminant governed by the brightness of surroundings and by the area over which the glare is distributed ?

To what degree is the sharpness of the shadows cast by concentrated sources of great brilliancy responsible for glare ? Is the effect of glare rendered more acute by variations in the intensity of an unsteady source of light ?

This question is interconnected with the quality of the light so far as absence from shaows is concerned. The requirements for the many different cases existing in practice, are so various, that it is impossible to give a general answer that would be of value. It should be here noted that the glaring effects produced by an unsteady source of light are much more serious than those produced by a perfectly steady light, as the eye is tired by the constant process of accommodating itself to the flickering of the light, quite apart from any accommodation to the varying intrinsic brilliancy of it.

5. Is there any reliable and simple physiological test by which it can be readily ascertained whether an existing system of illumination is open to objection, on account of glare ? Could the opening and closing of the pupil aperture be so used ?

The best test would probably be to personally undertake the ordinary work carried on in the worst illuminated part of the room in question, the test to last for one or two hours. The simplest test is to stand with one's back towards the wall and look upon a brightly illuminated object placed near the opposite wall : if one then obscures the source of light with an opaque screen, for say one or two minutes and then quickly removes this screen, the pupils of the eyes will, if the glare of the

light is too great, be over-contracted. The result will be that the wall in the neighbourhood of the source of light will then for an appreciable time appear to be less brilliantly illuminated than it was previously. With a properly and comfortably illuminated room using either the indirect or semi-indirect arc lighting system, it will be found that the contraction of the pupils of the eyes, when the screen is removed, will be exceedingly small, and that it will be hardly possible to notice any variation in the illumination of the objects in the neighbourhood. On the other hand, if the room is illluminated by screened sources of light, such as, for instance, gas lamps or incandescent lamps hung too low, a considerable difference in the illumination will be noticed.

6. What instruments are available for measuring in a simple manner the intrinsic brilliancy of any luminous object ? And what accuracy may be expected in such measurements ?

For this purpose the ordinary apparatus used for measurements of low luminous intensity is suitable. One would recommend measurement of the luminous intensity of the surface, and divide this by the area of the surface, and in this way obtain the surface or intrinsic brilliancy.

7. Is excess of light of all colours equally harmful ? To what extent are the prejudicial effects of incautious exposure to brilliant sources of light due to utra-violet rays ?

The most unsuitable rays for the eyes are :—

(*a*) The heat rays.

(*b*) An excess of ultra-violet rays.

8. Is the intrinsic brilliancy of some sources used in the streets too high ? And would a restriction of the existing brightness prove beneficial from the point of view of traffic, &c. Suggestions regarding the avoidance of glare from the headlights of vehicles, &c.

Yes, particularly when used in dark streets. The lamps used on motor-cars and bicycles should have a screen over the upper half, say of opal glass, which has the advantage of throwing a modified light upwards, so that it would be possible for the driver of the motor-car to observe objects in the neighbourhood, whilst the stronger low half would serve to light the road and give warning at a distance.

10. Should any recommendations as to the limiting brightness of illuminants, and illuminated surfaces, such as shades, &c., in interiors, be made from the artistic standpoint ?

In this case it is necessary to distinguish between :

(*a*) Ordinary domestic or business rooms.

(*b*) Large reception rooms, halls, and places where special illumination, which in the ordinary way would be uncomfortable, is desirable.

(*a*) For such places one would naturally use screens and shades, so that as far as possible the eye is screened from the source of light, the most desirable form being shades like two truncated cones joined at their apices, with the bases horizontal, one facing upwards and one downwards. Such an arrangement would procure for a room perfect illumination without any glaring effects on the eye.

(*b*) For such places the conditions mentioned in (*a*) above may be complied with, but in many cases it is desirable also to have unscreened lights, and these should be placed as high up as possible.

The Illuminating Engineering Society.

(Founded in London, 1909.)

New Members of the Society.

As announced elsewhere, the gentlemen whose names had been submitted for membership of the Illuminating Engineering Society at the meeting on January 11th, 1910,* were formally declared Members of the Illuminating Engineering Society at the meeting held on February 15th.

Honorary Members.

The following gentlemen have been nominated Hon. Members, in accordance with the constitution of the Illuminating Engineering Society, Articles 5 and 18,† which empowers the Society to nominate each year as Hon. Members three authorities who have rendered distinguished services in connexion with the development of illumination :—

Preece, Sir William, K.C.B., F.R.S., &c. Consulting Electrical Engineer, Past President of the Institutions of Electrical and Civil Engineers. Gothic Lodge, Wimbledon, London.

In recognition of valuable pioneering work in connexion with the measurement of illumination.

Swan, Sir Joseph, M.A., F.R.S., D.Sc.,& Past President of the Institution of Electrical Engineers, 58, Holland Park, London, W.

In recognition of valuable services in connexion with electric lighting, and as one of the inventors of electrical incandescent lamp.

Vernon Harcourt, Prof. A. G., M.A., F.R.S., Past President of the Chemical Society, Metropolitan Gas Referee, &c., St. Clare, Ryde, Isle of Wight.

In recognition of valuable services in connexion with photometry and the invention of standards of light.

In addition the names of the following gentlemen have been duly submitted to and approved by the Council and were read by the Hon. Secretary at the last meeting of the Society on Feb. 15th :—

Ordinary Members.

Walmesley, Prof. R. M. *D.Sc., F.R.E.E., &c.*	Principal of The Northampton Institute, 28, St. John Street, London, E.C.
Bayliss, Dr. W. M. *MA., D.Sc., F.R.S.*	Assistant Professor of Physiology of University College, London, St. Cuthbert's, Hampstead Heath, London.
Clinton, Prof. R. M.	Assistant Professor of Electrical Engineering, University College, London, 52, Claremont Road, Highgate, London.
Ettles, Dr. W. J. W. *M.D., F.R.C.S.E.*	Ophthalmic Surgeon, Pathologist to the Royal Eye Hospital, London, 34, Wimpole Street, London, W.
Palowkar, R. M.	Electrical Engineer and Draughtsman, In Charge of Photometer Room and Test Rooms of, Messrs. The Imperial Lamp Works, Brimsdown, 67, St. Paul's Road, Highbury, London, N.
Hart, J. H. E.	Late Chief Engineer P.W. Dept., India, 9, Pendennis Road, Streatham.
Taylor, H. J.	Electrical Engineer, 63, Queen Victoria Street, London, E.C.
Ernst, A. A.	Consulting Lighting Engineer, 103, Park Avenue, New York.

Corresponding Members.

Grau, Prof. A.	XIII. Wattmanngasse 28, Vienna.
Lux, Dr. H.	Editor of the *Zeitschrift für Beleuchtungswesen*, Director of the Beleuchtungs-Technische Laboratorium, 91, Buelowstr., Berlin.

Among others who have expressed a desire to become members of the Society since the last meeting of the Council, we may mention the names of Mr. H. Mordey, Past President of the Institution of Electrical Engineers, and Mr. T. E. Slaughter, Distribution Engineer, London Electric Supply Corporation.

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* A list of these names will be found in *The Illuminating Engineer*, Lond., Feb. 1910, p. 131.

† See *The Illuminating Engineer*, Lond., vol. 2, June, 1909, pp. 377 and 378.

Illuminating Engineering Society.

(Founded in London, 1909.)

First Anniversary Dinner

HELD AT THE

Criterion Restaurant, London, W.

THURSDAY, FEBRUARY 10th, 1910.

THE PRESIDENT, PROF. S. P. THOMPSON, D.Sc., F.R.S., IN THE CHAIR.

Prof. J. S. Haldane, F.R.S., *Professor of Physiology at Oxford University &c.*

Mr. J. W. Helps, *President of the Institution of Gas Engineers.*

Prof. A. G. Vernon Harcourt, M.A., F.R.S., *Hon. Member of the Illuminating Engineering Society.*

Sir H. Trueman Wood, *Secretary of the Royal Society of Arts.*

THE PRESIDENT, Prof. S. P. Thompson, D.Sc., F.R.S.

Prof. A. D. Waller, M.D., F.R.S. *Treasurer of the Physiological Society.*

Dr. T. M. Legge, H.M. *Chief Medical Inspector of Factories.*

Mr. W. Mordey, *Past President of the Institution of Electrical Engineers.*

Mr. W. Finlay, *President of the Electrical Contractors Association.*

Mr. H. D. Searles Wood F.R.I.B.A., *Chairman of Council of the Royal Sanitary Institute.*

Dr. J. Herbert Parsons, F.R.C.S. *Chairman of Council of the Illuminating Engineering Society.*

Mr. A. P. Trotter
Mr. W. J. A. Butterfield
Mr. F. W. Goodenough
Mr. S. Hamp
Mr. T. J. Hamp
Prof. J. T. Morris
Prof. W. C. Clinton
Mr. L. Fox

Mr. Chas Ingrey
Mr. G. R. Gill
Mr. J. S. Pollock
Dr. W. Ettles
Dr. T. G. Lyon
Mr. J. H. A. Baugh.
Mr. S. Cowper Coles
Mr. J.T. Inman
Mr. G. Campbell

Mr. J. Darch
Mr. E. G. Sheppard
Guest of Dr. Parsons
Dr. R. Lessing
Miss Runk
Mr. H. Harding
Mr. A. W. Dow
Mr. J. S. Dow

Mr. N. W. Prangnell
Mr. Haydn T. Harrison.
Col. W. F. Leese
Mrs. Leese
Mrs. E. M. Francis
Major G. C. Glynn
Mr. J. C. Inglis
Mr. C. Le Maistre, *Gen. Sec. of the International Electrotechnical Commission*
Guest of Mr. L. Gaster

Mr. J. Wyatt Ilfe, *Hon. Treasurer of the Illuminating Engineering Society*

Mr. L. Gaster, *Hon. Secretary of the Illuminating Engineering Society*

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

First Anniversary Dinner.

(Held at the Criterion Restaurant, London, W., on February 10th, 1910.)

THE First Anniversary Dinner of the Illuminating Engineering Society was held at the Criterion Restaurant (London, W.) on Thursday, Feb. 10th.

It is interesting to recall that it is just a year since a dinner was held at the same restaurant for the purpose of forming the Society (see *The Illuminating Engineer*, March, 1909, p. 154).

On that occasion the Society enrolled about thirty members, and it was decided that the time was ripe for pressing on with its organization. A Committee was therefore appointed to consider the framing of statutes, &c. This Committee subsequently reported at a general meeting of the Society on May 25th, 1909, when the suggested constitution of the Society was adopted and the Committee reappointed with power to add to their numbers, as the nucleus of the first Council of the Illuminating Engineering Society.

Subsequently the Society had the privilege of receiving the consent of Professor S. P. Thompson, D.Sc., F.R.S., to act as the first President, and Professor Thompson delivered an address at the inaugural meeting on November 18th.

During this period the membership of the Society had risen to about one hundred and fifty members. It is gratifying to observe that in the short time that has elapsed since this step, the number of members has increased to about two hundred.

The proceedings at this Inaugural Meeting served to explain the impartial, and international attitude which the Society desired to maintain, and the wide support which it might expect to receive. More recent events have fully confirmed these aspirations. The account of the first anniversary dinner which follows perhaps illustrates even more strikingly the number of different societies and professions which cordially recognise the need of the Illuminating Engineering Society.

On page 192 will be found a scheme of the position of those present as prepared just before the dinner. On the eve of the meeting a telegram was received from the President expressing his great regret that, owing to indisposition, he could not be present, and wishing the Society a pleasant and successful evening. In his absence, the chair was kindly taken by Sir Henry Trueman Wood, the Secretary of the Royal Society of Arts. Mr. L. Gaster, Hon. Sec. of the Society, also read letters which had been received from a number of influential authorities representative of different aspects of illumination, expressing regret at their inability to be present. Among these may be mentioned, the Presidents of the Royal Society, the Institution of Electrical Engineers, the Physical Society, and the Opthalmological Society, Sir William Crookes, Sir Joseph Swan, Professor Vivian Lewes, Sir Boverton Redwood, Dr. W. M. Bayliss, Mr. G. M. Light (Hon. Solicitor to the Illuminating Engineering Society), &c.

Toast:—"The Prosperity of the Illuminating Engineering Society."

The Loyal Toasts having been duly honoured,

Mr. A. P. Trotter, M.I.E.E., proposed the toast of "The Prosperity of the Illuminating Engineering Society," and said: Ladies and Gentlemen, I have to propose to you to-night "The Prosperity of the Illuminating Engineering Society," or, in other words, the health of the Society. The Society is healthy. It is a baby of one year old

to-day, a very promising child; a child which has hardly learnt to talk. It began to say something last month and is going on to finish its remarks next week.

The custom we have of celebrating these events by a dinner is almost exclusively an English one. Someone has said that if a comet struck the world and demolished almost everything and there were twenty Englishmen left, as soon as possible they would meet together to celebrate the event by a dinner. People have said to me: "What is this Illuminating Engineering Society?" Well, at least we can say it is a Society that dines. And after all there are some societies who do nothing but dine, and excellent ones they are too.

We have yet to make known our intentions more widely amongst scientific people than they are at present. There are no end of things we have to do, and the importance of the Society cannot fail to impress itself upon people. Think of the millions of pounds sterling invested in the production of light! Whoever thinks of investigating the results by measurement? Some people say that the results are dividends; others say that the results are candle-power. As a scientific Society, of course, we shall be critical. Some people are always critical, others are always optimistic. There is room for both, and a Society would hardly get on without both. It would be rather terrible if we were nothing but critics, and it would be rather useless if we were nothing but optimists. There is room for any amount of science and mathematics, and any amount of theory; but you can have too much theory.

There is one member of the Society we cannot help missing to-night, that is Sir William Preece. I saw him to-day looking very well and hearty, but he says he is absolutely forbidden by his doctor to be out at night, and he asked me to communicate to the Society how sorry he is not to be able to attend. Sir William Preece was the first man in this country, I believe, to recognise illumination as we study it. He was the man who, when the City was lighted by big arc lamps twenty-five years ago said: "Let us put aside candle-power and measure the illumination." He it was who began that branch of science which will have an important future in our Society. With these few words, I ask you to drink to the prosperity of the Illuminating Engineering Society. (Applause.)

Response.

The Chairman: I think the reply to this toast ought to have been put into the hands of one of the members of this Society who have done more of its work. As I am really filling a gap I can only say that I wish our President was here to give you one of those interesting addresses which he always does in so eloquently and happy a manner. I have followed the working of the Society with very great interest, and though I must admit that at first I viewed with some little regret and some little doubt the establishment of a new Society, when there are already so many competing for the public support, I have yet come to see, from a study of your transactions, that after all there is room for a very special Society such as you gentlemen have formed. As the progress of science goes on, it becomes more and more specialized and more difficult for anyone who is only a mere amateur to follow the progress of the various branches into which science divides and subdivides itself. Personally, I have to admit that there is a great deal of value in an institution which can study illumination as a whole rather than the means by which that illumination is produced. There are many engineering societies besides the great general societies which deal especially with the two principal means of illumination, electricity and gas; but I am sure there are a great many problems which cannot be dealt with properly either from the side of the electrical engineer or the gas engineer, and it is an excellent thing that an institution should be founded to deal only with the very difficult problems which are presented to it. From what I know of this Society's work, I do not think it has any need to be ashamed of its work during the past year, and there is every reason-

able prospect in the years to come, when it shall no longer be a young institution, but an old-established and important Society, it will have a record to look back upon of which it may be proud. I am sure that all you gentlemen will agree with the hope that the Society will meet with prosperity, and more than that, you will all of you do your best to make the Society not only a prosperous one, but also—what is of more importance—a useful one. (Applause.)

Toast: "Our Honorary Members."

The Chairman: It now becomes my duty to propose the health of "Our Honorary Members," and it affords me very much pleasure to do so, because they are three very old personal friends of mine—Sir William Preece, Sir Joseph Swan, and Prof. A. G. Vernon Harcourt. There is only one of them present, and I could wish I had had more opportunities of seeing him, because it so happens that I know the other two a great deal better than I know Prof. Harcourt. At the same time, I have worked with him in a humble position in the British Association years ago. when he was the esteemed Secretary of the Association. I then got to know his work, and of course, we all know his scientific reputation. I think the Society is fortunate in being supported by three such eminent men. I have great pleasure in proposing the toast and coupling with it the name of Prof. Vernon Harcourt. (Applause.)

Prof. A. G. Vernon Harcourt: Ladies and Gentlemen, I did not expect to be called upon to speak; indeed, I took the precaution before I accepted the pleasure of dining among you of writing to the Hon. Secretary to say that at my advanced age I thought it was hardly fair, having done my share of speaking on other occasions, that I should be called upon to do so. However, after the kind words used by Sir Henry Trueman Wood, I must say that I was gratified by the offer which was made by your President and Secretary when they invited me to become, an Hon. Member of your Society, which deals with the subject with which I have long been connected, and also by the invitation to come here this evening. I am sorry that I alone of the three should be here. I quite agree that it is a happy thought to bring together electricians and those who are interested in the subject of illuminating gas so that they may confer as to the modes of measuring the amount of light and can compare notes, each giving information on his own subject of the means by which that light is produced. There is always a difficulty in starting a new Society because of the number of societies already in existence. We already have the Institution of Gas Engineers and the Institution of Electrical Engineers. Both these subjects are growing, and I have no doubt that, advantage will be gained by the discussions which take place at your meetings and by the bringing together of those who are concerned with these two modes of illumination. I hope that the result of the labour of your Society will be that there will be a large advance in the knowledge of these subjects, and I doubt not that this newly-founded Society will bear a large share in that advance. I thank you gentlemen for your kindness in drinking my health and that of my two colleagues. (Applause.)

Toast: "Kindred Societies."

Mr. L. Gaster: Mr. President, Ladies, and Gentlemen,—The toast which I have the honour to propose is one which must appeal with special force to members of the Illuminating Engineering Society. For what is the main feature of our programme? *Simply co-operation.* We desire to benefit by the experience of other societies and other nations than our own, in the special branches of illumination with which they are connected. We wish to bring together and concentrate the efforts of all those, engineers, architects, physiologists, &c., who are able to give advice regarding the improvement of our methods of using light.

No one individual to-day—no society even—can claim a monopoly of knowledge. But a suitably constituted society whose members include authori-

ties on different aspects of the subject of illumination can by their united efforts, and by harmonious working with other societies, gather information in a way in which no individual can hope to do. A few generations ago, when science was less complex, and when methods of illumination were few and primitive, the need for such a Society as ours was not felt to the same extent. But to-day when new illuminants are springing up on all sides and new uses for illumination are every day becoming evident, we can only keep abreast of this progress by union, mutual help, and co-operation.

It is, therefore, very pleasant to us to see here so many representatives of different aspects of illumination who, in their respective fields, have done so much to develop what is now termed "illuminating engineering."

Any new society values very highly the sympathy of those of older standing. It has been very gratifying to us to feel that our efforts have met with cordial encouragement from the Royal Society of Arts, which is one of the oldest Societies in this country, having been in existence for over 150 years. Their distinguished secretary is with us this evening. Any one who has any knowledge of the organization of a large society of this kind must realize how great is the burden of work which Sir Henry Trueman Wood has borne in extending the influence of the Royal Society of Arts during his long period of office. I have always felt that the wide and impartial views of this Society are akin to those which we desire to promote. In the fifteen years during which I have been a member of that Society I have listened to many such discussions, and have always been impressed by the impartial platform presented. As regards illumination, too, reference to the early records of the society shows that this impartial attitude has always been preserved. The Royal Society of Arts has encouraged lectures on all illuminants, and only last year they established an important precedent by devoting the Cantor Lectures to the subject of illumination. Sir Henry himself has taken a keen interest in all matters connected with light and photography. Our Society owes him one special debt—he was among the first to suggest for our first President Professor Silvanus Thompson.

We are also delighted to see present this evening representatives of the Institutions of Gas and Electrical Engineers. Mr. J. W. Helps is a name which is a household word in the gas industry, and I have read with keen appreciation several addresses of his in which he gave valuable and encouraging advice to the rank and file of his profession. Recently Mr. Helps has participated in a piece of work which enlists, to a special degree, the sympathy and support of the Illuminating Engineering Society, namely, the establishment of an international unit of light. I feel confident that the general favour which has been given to this suggestion was in no small measure due to the co-operation of representatives of the gas industry and the Gas Referees in the work of the International Electrotechnical Commission; this work, it is pleasant to note, was carried out with the co-operation of our own President.

I do believe that there are great possibilities of co-operation between those interested in gas and electric lighting. Many of our municipalities now manufacture both gas and electricity, and a review of recent improvements in connexion with gaslighting suggests that gas engineers are coming to realize that a knowledge of electricity is a valuable weapon in their own interests. It is very satisfactory for us also to see here Mr. Mordey, who was last year President of the Institution of Electrical Engineers. He has more than once given us proof of his sympathy with the movement. The advent of the metallic filament lamp has profoundly modified electric lighting, and done much to draw the attention of electrical engineers to the need for better methods of illumination. This interest, I feel convinced, will prevail, and become even more general as time goes on.

Turning next to the physiological side of illumination, I feel sure that the Society will extend a very cordial welcome to Professor A. D. Waller, whose fascinating work on the retina of the eye has a very intimate bearing on problems of illumination, and incidentally on electrical phenomena as well. We have recently had an excellent illustration of the importance of knowing what happens inside the eye, during our discussion on "glare." In order to trace out the effect of a bright luminous image on the retina and to ascertain the effects of light of different qualities, we must follow out the subject physiologically.

Now this is the kind of work which illuminating engineers must look to the physiologist to perform. But it is not always easy, without co-operation from both sides, to establish the connexion between the physiological effect and the physical cause. I can recall some experiments of Prof. Waller on fatigue effects and the connexion between the stimulus and the sensation of light which would seem to have a very direct bearing on the problems which we have recently been discussing. This is only one instance of the innumerable lines of research in which the physologist could help us, and I hope that many authorities, such as Prof. Waller, will do so. Let us persevere in inducing people to take an interest in these matters, and they will ultimately fall in with the suggestion.

Now I have just been speaking of the complex field for study in the observation of what goes on inside the eye. But there are other fields in which the *hygienic* rather than the physiological aspects of illumination have to be considered. During the last few years wonderful progress has been made in the subject of sanitation. We have seen our death-rate gradually falling, and we have seen the introduction of legislation insisting upon the value of fresh air and ventilation in factories and workshops.

And apart from the effect of illumination on the health of employees, it is probable that many serious accidents can be traced to bad lighting. I notice that the Fidelity and Casualty Co. of New York have recently issued a pamphlet on the 'Prevention of Industrial Accidents' of an extremely exhaustive character, and among the general causes of accidents defective illumination is placed first.

But it is becoming also realized that if we consider the general health of our population in the above respects we should especially consider *their eyes*. We find new measures being introduced dealing with the eyesight of school children. Is it not therefore natural that while doing this we should study not only defects of eyesight, but the conditions of illumination responsible for them? This is a field in which we strongly desire te see the co-operation of the lighting engineer and the sanitary and medical authorities, and I think that a gratifying precedent has been set by the presence as our guest of a representative of the important Royal Sanitary Institute, Col. Lane Notter, who very kindly came specially and at very short notice, in the unavoidable absence of the Chairman of the Institute, Mr. H. D. Searles Wood.

And now, last but not least, let me say a word or two on an entirely different aspect of lighting. I mean the æsthetic, and what may be called the "architectural" standpoint. It is obviously necessary in buildings of historic importance and artistic pretensions to consider the illumination very carefully. If we attempt to light such buildings artificially at all, surely the architect must desire that this method of illumination should be very carefully selected. If we have beautiful objects to see, surely we should be careful how to arrange the light by which they are illuminated! In many such cases we have a very complex problem to solve. We may have to provide sufficient illumination from the utilitarian standpoint, and we have also to be sure that the new illuminant is in harmony with the old surroundings. In such cases the architect responsible should have a very keen interest in illumination, and we, as a society, are very anxious to number among our members architects who have made a study of such subjects.* And then

there are also numberless public buildings in which co-operation between the architect and the engineer might be very beneficial to the system of lighting adopted. It may be that architects have not always realized that the system of illumination comes so much within their province, and do not seem to have hitherto made the subject of illumination part of the regular curriculum. But, now that the movement for better illumination is spreading, I feel sure that they will come to do so, and I look forward to a time when the matter will form the subject of frequent discussion between our own and the architectural societies, and in this connexion I should like to add to the list of names coupled with this toast that of Mr. Stanley Hamp, A.R.I.B.A., one of the members of the Council of the Illuminating Engineering Society.

Perhaps I have said enough to suggest the many threads of common interest which bind the various existing societies to our own, and I ask you to drink with enthusiasm to their better mutual understanding and co-operation.

Response.

Sir Henry Trueman Wood: Ladies and Gentlemen,—I ask you to accept my very sincere thanks without bothering you with any further speech.

Mr. J. W. Helps (President of the Institution of Gas Engineers): Mr. Chairman, ladies and gentlemen,—Mr. Gaster has given you what may be called the key-notes of this Association: firstly, co-operation; secondly, impartiality. Now I am a great believer in the value of co-operation, and I have during the past few years had a special reason for my belief in that principle. I have had something to do with the question of the photometric unit, and in connection with the international commission which was held in Zürich and Paris, I had the pleasure of meeting and working with representatives of the electrical engineering profession in such a way that I can safely look back upon the hours I spent in their company as some of the happiest and most useful in my life. I have also had the pleasure of meeting gentlemen connected with the electrical profession during the discussions on the unit of light in England, and I can say the same thing.

Then with regard to impartiality; I believe so long as the Society keeps that in the forefront its success is assured. So long as the question of competition can be kept away from the platform, then success must attend our efforts. It is all very well to believe in competition; I am a great believer in it. Had it not been for competition this subject would not occupy the position it does to-day. The competition which we should all encourage in this Society is the competition amongst ourselves as to how we shall deal with the subject of illuminating with which we are connected and find out the difficulties and do our utmost to bring those illuminants into such a condition that they will meet the circumstances for which they were intended and do good to the community at large. So long as we do our best to find out the why and the wherefore of the conditions we have to discuss, so long shall we be doing our duty not only to ourselves but also to the world at large. I do most heartily thank you for your kind invitation, and on behalf of the Institution of Gas Engineers I recognise the good work that this Society is doing and will do, and wish it every success. (Applause.)

Mr. W. Mordey (Past President of the Institution of Electrical Engineers): Mr. Chairman, ladies and gentlemen,—I represent an Institution of six thousand members, many of whom have spent a great deal of time in studying the subject that specially interests this Society. I fear that we, the Institution of Electrical Engineers, are rather a retrograde body. At one time we thought electric light was the great thing for us to study, but now lighting interests us comparatively little and the questions which interest us are mostly connected with such things as energy, and you have come to the rescue by founding a Society which is going to deal with this great question of illuminating engineering.

Something has been said about co-operation. I am quite sure that we, the electrical engineers, shall always be

very happy to co-operate in any way we can with this Society, and I think we have a very good reason for so doing, because ever since we were formed, 37 or 38 years ago, we have been helped very materially principally by one great Society, the Institution of Civil Engineers. Had it not been for the hospitality of that great Institution, and also the hospitality of the Royal Society of Arts, the probability is we should not now be in the position we are—the owners of a very fine house indeed.

And now that we have a roof over our heads, I am sure we shall imitate the example set us by the older societies, and shall be very glad to do what we can to help support and shelter other societies that are springing up as special branches of knowledge develop. The Illuminating Engineering Society has a special field, and it is difficult to see how the work it has to do could very well be done by any other Society. The Institution of Electrical Engineers could hardly take it under its wing because the study of illumination must be carried on by people who are not only electrical engineers, but by our friends the gas engineers, and by those who are not connected with electrical work or any other branch of engineering. I was very glad to hear what Mr. Helps said about competition. We all owe a great deal to competition in science and in business. This Society seems to have taken up what I cannot help thinking is perhaps the most important practical problem in physics and in engineering. With the very best appliances that can be used I think I am right in saying that there is no electrical supply system in this country or in any other that delivers to its customers five per cent. of the heat energy of the coal that goes into its coal bunkers. We have a great problem before us to improve on that very poor result.

But when we ask how the problem presents itself to illuminating engineers we find a still further loss. I am sure I am not under-stating the fact when I say that there is no system of engineering for supplying the needs of the public that delivers as light ½ per cent. of the energy with which it starts to work. That surely is a great problem and one which this Society will help to solve. May I remind you of some words Lodge wrote twenty-nine years ago when he said: "A little boy turning a handle, if his energies were suitably directed could provide all the light for a City like London." May I remind you of another thing. Your President, Professor Silvanus Thompson, in a little book called 'The Manufacture of Light,' reminds us of the work of Langley on the efficiency of the glow-worm and creatures of that sort, and he says that the glow-worm as a giver of light from energy is 400 times more efficient than any light we know of. Langley has told us many things about the glow-worm, and there is one thing I should like to mention, seeing that you have in your Society members of both sexes: the glow-worm is the lady who stops at home and looks about; it is the gentleman who has wings and can soar. (Laughter and Applause.)

Prof. A. D. Waller (Treasurer of the Physiological Society): Mr. Chairman, ladies and gentlemen,—I also came here absolutely ignorant of the fact that I should be called upon to address you. I feel rather an injured innocent from the fact that the words have been taken out of my mouth by Mr. Mordey, inasmuch as one thing that occurred to me to say was that from the energy point of view according to Langley the efficiency of the glow-worm and the fire-fly amounts to something like 98 per cent. of the energy they are able to supply.

Nevertheless I must trust to luck as regards being able to produce some other idea that may be worthy of the acceptance of this Society which shares with the Society I have the honour to represent the advantage of not yet possessing a home, for I take it there is no greater advantage than is enjoyed by a Society when it is in the stage of the oyster that has not yet opened itself to the blandishments of commerce. We have no organ of publicity, we have no home, and yet we believe we are a most healthy and thriving Society. We believe we are that by

virtue of the fact that we are doing what seems at first sight somewhat incongruous to a Society like the Illuminating Engineers, that is, we have successfully hidden our light under a bushel.

Another advantage is that we are an extremely greedy lot of people. We are exceedingly anxious to be illuminated; we like to be illuminated by the chemist, by the physicist, and we hope to be illuminated by the illuminating engineer. We believe that in the measurement of light we have a good deal to be taught. We know a little about light; we know if you take a light that is a certain distance from the eye and if you double the distance you will divide by four the energy with which that light strikes the eye. We believe that knowledge has commercial applications, and in its proper place we insist upon those commercial applications being put into practice. I should like, sir, to imitate your most excellent example by not making a lengthy speech and return my most hearty thanks for the kindness with which you have drunk our health. (Applause.)

Col. Lane Notter: Mr. Chairman, ladies and gentlemen,—I have to plead some extenuating circumstances because on very short notice I was asked to take Mr. Wood's place this evening and to express his regrets at not being able to be present. I am afraid it has placed rather a difficult task upon me, as I shall speak from the health point of view. There is perhaps no subject at present which invites attention more from this standpoint than that of illumination, nor one which up to the present has been more or less neglected, particularly in our public schools. On behalf of the Royal Sanitary Institute we shall be most willing to co-operate with you in every way in our power for the elucidation of those subjects which have been so admirably placed before you this evening and to arrive at some conclusion which will give relief to the present system of lighting, particularly in large public buildings. I can only say from personal knowledge that the architects who are connected with that Institute are keenly alive to what is necessary on this subject, and I am sure they will co-operate with your Society in every way they can in the hope that the results will be useful to the general public. I thank you for connecting the Royal Sanitary Institute with the toast. (Applause.)

Mr. S. Hamp: Mr. Chairman, ladies and gentlemen,—I feel it a great honour to be called upon this evening to respond on behalf of the architectural profession. Although I am only a feeble representative of that body, yet I feel, after the words of your worthy Secretary that I should make an effort to disabuse his mind upon the point which he raised. I am sure that this Society will appeal more strongly to architects than perhaps to any other profession for it is the architect to whom the illumination of a building is of great importance. I am sure that if Mr. Gaster will employ his energies in bringing the object of this Society before the members of the architectural profession he will have a very large number of them join the Society, who will take advantage of the opportunities it will afford them. Up to the present we as architects have not perhaps given that attention to illumination which we might have done, and often I am afraid the admirable design of a room has been spoilt by the poor attempt at illumination. We have not studied the subject as we should, and I feel confident that this Society is going to put within our reach the means of doing so. We have as our President a very distinguished gentleman, and his very name spells success to the Society; in our Hon. Secretary we have a very enthusiastic hard worker, and given those two, I am sure success is before us.

Perhaps I may be allowed to suggest that the Society might find occasion to deal with the respective illuminants as applied to a country house which, after all, is important to architects. If you can explain to us the advantages or disadvantages of the numerous illuminants which we have to consider, we shall be very greatly helped in our work. I can only say I feel it a great honour to be coupled with the toast, and I thank you all very heartily for

the way in which you have received me. (Applause.)

Toast: "Our Guests."

Col. W. F. Leese: Mr. Chairman, ladies and gentlemen,—It is my pleasant duty to propose the toast of the guests. We are very pleased to see them here this evening. This is our first dinner, and we hope next year we shall have more guests and there will be more of us to entertain them. We believe their presence is a tribute to the purity of our aim and the catholicity of our sympathy. We believe as time goes by we shall be able to show them that this Society means to do good work, not for itself, not for any phase of the lighting industry, but on behalf of all. We have associated with us as our guests representatives of the great professions which look upon all the others with sympathy—I refer to the Sanitary Authorities and the medical profession. I ask you to drink to the health of our guests coupled with the names of Dr. Legge, Mr. W. Finlay, and Mr. Butterfield. (Applause.)

Responses.

Dr. T. M. Legge (H.M. Medical Inspector of Factories): Mr. Chairman, ladies and gentlemen,—I thank Col. Leese very much for coupling my name with this toast. I belong to a Government Department which no doubt will be one of the very first to feel the gentle pressure of your Society. We shall have to awake from our slumbers and turn up the lights. When I go into a factory I always try and go with as detached a mind as possible, so as to lose nothing. What adds greatly to the enjoyment of my work is the wonderful involuntary illuminating effects that one finds—the white glow from the brass work of the workshop of the brass workers, the glass house, or the iron rolling mill.

But, leaving the sentimental and coming to what is practical, there is no doubt that, owing to increasing rents, one class of workshop is on the increase, namely, underground basement rooms, and we want a standard of light for them. There is a word of warning I want to offer, and that is, you ought not to try and enter into competition with the sun. If the sun can possibly get in from without, you must not try and overcome that by illumination from within. There is one kindred Society with which I think your work dovetails more closely than with any other, and I hope you will be able to give it a leg-up, that is the despised Smoke Abatement Society. I feel there is an enormous amount of truth in the saying that where the sun does not get the physician will. I thank you very much. I am sure you will find the Home Office very sympathetic with your efforts. (Applause.)

Mr. W. Finlay (President of the Electrical Contractor's Association): Mr. Chairman, ladies and gentlemen, I have to thank you for the cordial reception you have given me as a representative of the Electrical Contractor's Association. I shall have very much pleasure at their next meeting in reporting to them the cordial reception I have received from you and the good work you have undertaken to do, because it is quite evident that there is much need for improvement with regard to many forms of lighting. Within the last few years we have made enormous strides. We have seen in the introduction of electricity different forms of lighting which have certainly been vast improvements over what preceded them.

We must remember we have more enemies to fight together than we have to fight amongst ourselves, and therefore I welcome this Society because it is a link between Electrical Contractors and gas engineers. Let us go hand in hand in the advance of science and of efficient lighting and so give our customers satisfaction whatever form of illuminant they propose to adopt. True, there is much to be said for both parties. I understand one of the aims of this Society is to lay before the general public the actual facts of the case so that the many mis-statements which are probably made on both sides will be corrected and true statements laid before the public as to the value and efficiency of each form of

lighting. I thank you for the very cordial way in which you responded to the toast. (Applause.)

Mr. W. J. A. Butterfield (Secretary to the Metropolitan Gas Referees) : It has given me very much pleasure to be your guest this evening. My interests in connection with methods of illumination have been varied. The success of this Society is, I think, assured, for several reasons. In the first place, you have been singularly fortunate in the choice of your first President, fortunate also in the choice of your Chairman this evening, and especially fortunate in your energetic Secretary whose enthusiasm will, I am convinced, establish the Society on a sound and permanent basis. I have always considered that artificial illumination can seldom be too good provided it is uniform and provided the effect of glare is avoided. I think a high degree of illumination is never harmful. When we hear people complain that illumination is too brilliant for them I always think it is time they should consider the propriety of retiring to bed. Gentlemen, I thank you very much.

Toast: "The Chairman."

Mr. F. W. Goodenough (Chief Inspector of the Gaslight and Coke Co.) : Before breaking up I feel sure that we should like all to express our gratitude to our Chairman, Sir Henry Trueman Wood, for so kindly consenting to preside at such short notice. I feel sure that the success of this dinner, which we have all so much enjoyed, is in no small measure due to his efforts, and it is my duty to ask you to drink his health and to express a very cordial vote of thanks for his services in taking the chair this evening.

Toast: "The Hon. Secretary of the Illuminating Engineering Society."

The Chairman: Gentlemen, I thank you most heartily for your kind remarks. There is one toast I should like to add to the list, and I am sure it will be cordially welcomed by all of you, namely the health of our Hon. Secretary. It is due to his energy and hard work that the Society has been started on its prosperous career. I have known Mr. Gaster for many years, and I think the Society is to be congratulated on having anybody who is willing to devote such a deal of time and thought to its affairs as he does, and so long as he is willing to give his time to the work the Society will be a prosperous one. I am sure you will all stand up and drink Mr. Gaster's health and congratulate him heartily on the result of a very arduous undertaking. (Applause.)

Mr. L. Gaster (Hon. Secretary of the Illuminating Engineering Society) : Mr. Chairman and gentlemen,—I shall not detain you more than one minute. I can assure you that this is one of the happiest days in my life. I need hardly say that all the work I have done has been to me a labour of love, and I feel I owe a deep debt of gratitude to all those who have so cordially supported my endeavours and co-operated with me to bring the Society into existence and launch it on what I hope will be a useful and prosperous career. It is only by the aid of such co-operation as you have seen exemplified to-night that we may hope to see the Society thoroughly successful and carrying out the work it is called upon to perform in an efficient manner. I thank you all from the bottom of my heart for the kind manner in which you have honoured the toast coupled with my name.

Some Difficulties Encountered in the Classification of Illuminating Petroleum.

By A. Guiselin,

Engineer to the Compagnie Industrielle des Petroles, and Secretary of the International Petroleum Commission, Paris.

In May, 1908,* I had the honour to contribute to this journal a short article pointing out that the combustion of illuminating petroleum might be favourably influenced by the height of the upper level of oil in the reservoir of the lamp. I was able to demonstrate on that occasion that the results, both as regards intensity of light and economy in its production, were much more satisfactory if the reservoir of the lamp was completely filled at the beginning of each test. In conclusion, therefore, I pointed out that the consumer would find it advantageous to employ a reservoir in which the upper level of the oil could, in a practical manner, be continuously maintained at a short distance from the burner of the lamp.

I have made use of this result in my subsequent experimental work and since that time, all the different qualities of petroleum submitted to me for examination have been tested on a new basis. As before a variety of burners in general use among French consumers has been employed, with this difference, however, that the burners were fitted on to a reservoir of a special predetermined shape and capacity, and that this reservoir was completely filled up at the commencement of each experiment.

Quite recently I have been able, proceeding on the above lines, to examine, in a most thorough manner, a variety of different qualities of petroleum, which have been imported direct into France for supply to the French public. My experiments were carried out on these varieties both in their original state and in various mixtures. I take this opportunity of publishing my experiences in this connection, believing that they enabled me to draw several conclusions, which might be of use in the debates of the International Petroleum Commission, whenever this question happens to be brought before it.

In the first place let me briefly recapitulate the methods pursued in my recent experiments, as well as those referred to in my former article :—

(1) All petroleum to be tested is first filtered in order to remove all trace of humidity, which may vary with different qualities.

(2) The same burners, wicks, and chimneys which served for the first experiment, are used during the whole

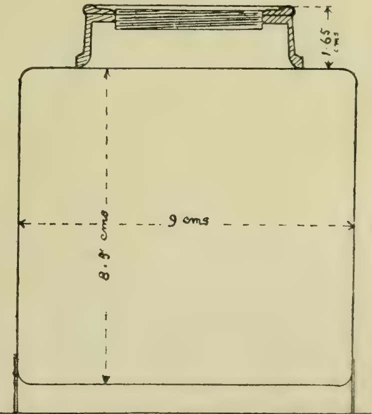


Fig. 5.—Reservoir of Lamp. Half size.

series of tests, care being taken to avoid any possibility of interchanging.

(3) Burner "Kosmos, Model B E" has been ommitted this time, as it is practically identical with the more strongly constructed "Kosmos W W" type, and the tests were made on the three Kosmos burners W W, K B,

* *Illuminating Engineer*, London. Vol. I., 1908, p. 244.

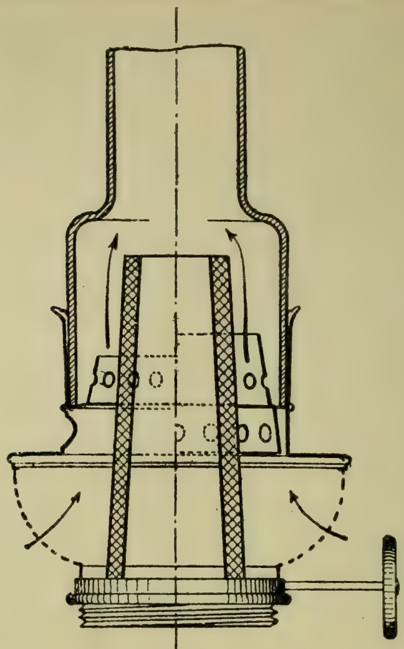


Fig. 4.
(Type not used in these tests).

Fig. 1.
Kosmos W.W.

"Kosmos" Burners (scale of 6/10).

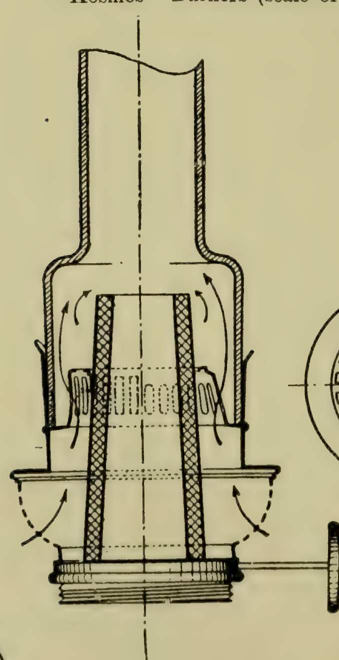


Fig. 2.
Kosmos K.B.

Fig. 3.
Kosmos H.S.

"Kosmos" Burners (scale of 66/100).

and H S—shown in Figs. 1, 2, and 3—only.

4. At the commencement of each experiment the reservoir, as represented by Fig. 5, was completely filled up and the lamp adjusted, so as to obtain the maximum intensity from a steady, non-smoking flame; that is to say, the lamp was so adjusted that the slightest raising of the wick would suffice to cause the flame to smoke.

5. The intensity of the light was measured by means of a photometer of the grease spot type at the end of the 1st, 3rd, 6th, 9th, and 10th hours.

6. The Luchaire petroleum standard was selected and accurately adjusted to give a light of 1 carcel by means of a standard carcel lamp; in this way it was possible to obtain illumination of identical colour on each side of the grease spot.

7. Finally the consumption of petroleum was estimated by the difference in its weight at the commencement and conclusion of each experiment.

The various qualities of petroleum tested have the principal characteristics shown in the Table I.

As may be observed, most of these

TABLE I.

Chief Properties of the Varieties of Petroleum Examined.

No.	Quality.	Locality Produced.	Density.	Flash-point.	Colour*
1.	Water White	Pensylvania, U.S.A.	0·787	40°	½
2.	Standard White	,,	0·797^{9}	35°	½
3.	Light Petroleum	North America	0·802^{5}	37°	3
4.	Ordinary ,,	,,	0·808^{7}	38°	4
5.	Illuminating Oil, de luxe	Galicia	0·809	38°	2–3
6.	,, ,, Ordinary	,,	0·816	35°	>4
7.	,, ,, (Roumanian)	Roumania	0·806^{1}	35°	1
8.	,, ,, de luxe	Texas, U.S.A.	0·825^{4}	41°	2
9.	Petrole de luxe	French Production	0·801^{6}	38°	1
10.	,, Ordinaire	,,	0·814	35°	3

* The colour of oil is specified by reference to distilled water and aqueous solutions of potassium bichromate of various strengths.

Tint 0 corresponds with distilled water.
1 ,, ,, an aqueous solution of 5 m/mg per litre of pot bichrom.
2 ,, ,, ,, ,, 10 ,, ,, ,, ,,
3 ,, ,, ,, ,, 20 ,, ,, ,, ,,
4 ,, ,, ,, ,, 40 ,, ,, ,, ,,

TABLE II.

Quality of Petroleum.	Mean Consumption.						Output of Light during 10 Consecutive Hours (Carcel-Hours.		
	Per Hour.			Per Carcel-Hour.					
	Burner No. 1.	Burner No. 2.	Burner No. 3.	Burner No. 1.	Burner No. 2.	Burner No. 3.	Burner No. 1.	Burner No. 2.	Burner No. 3.
1. Water white	3·69	39·1	38·0	35·9	35·7	35 30	10·28	10·94	10·76
2. Standard ,, ...	38·5	39·1	38·8	37·93	38·35	37·91	10·15	10·20	10·23
3. Light Petroleum	35·6	38·1	37·8	37·1	37 01	34·14	9·44	10·30	11·08
4. Ordinary ,, ...	33·5	33·4	35·3	37·9	37·75	36·28	8·85	8·84	9·73
5. Illuminating Petrole "de luxe"	35·3	37·1	39·3	44·12	45·80	37·66	8·00	8·10	10·43
6. ,, ,, Ordinary	28·8	29·1	36·0	50·75	50·91	42·02	5·67	5·71	8·57
7. ,, ,, (Roumanian)	35·5	34·3	37·3	38 60	40·00	39·30	9·20	8·57	9 48
8. ,, ,, de luxe	34·4	33·5	36·7	36·90	36 9	35 85	9·32	9·08	10 24
9. Petrole de luxe	38·7	38·6	39·4	35·6	37·20	39·10	10 87	10 38	10·C0
10. Petrole Ordinaire	38·4	36·9	37·6	42·3	42·14	38·64	7·66	8·76	9 74

N.B.—Particulars of the qualties of each of the types of petroleum mentioned above will be found in Table I. The figures supplied by the author regarding the intensity at the end of the 1st, 3rd, 6th, 9th, and 10th hours have been omitted but are obtainable from 6–9.

Burner No. 1 is the Kosmos K.B. 12 in. Burner No. 2 is the Kosmos W.W. 12 in.
Burner No. 3 is the Kosmos H.S. 12 in.

qualities of petroleum are of American origin, while the other varieties from Galicia and Roumania have been refined in the country in which they were produced, so as to be suitable for use in the customary French lamps (Figs. 1, 2, and 3). For comparison I have selected two excellent French qualities of petroleum which are sold in the market under the names of "Petrole de luxe" and "Petrole ordinaire," and are composed of a mixture of Pensylvania oil, in fairly large proportion (35 to 50 per cent.), with Roumanian oil (Busteman), which latter cannot in its pure state be burnt in the lamps mentioned.

The results I have obtained from these experiments for each of the burners employed are shown in the following table :—

From this last table it will be seen that it is hardly possible to classify in order the qualities of petroleum with regard to the two essential points, intensity and economy of consumption —not even when considering one type of Kosmos burner only.

Nevertheless it is noticeable that in most cases the "Luxe" qualities give better results, while the ordinary qualities come last. But the rule is not general, inasmuch, for example, that the French "petrole de luxe" is very satisfactory when used on Kosmos W W and K B burners, while it gives only a mediocre result when used on Kosmos type H S.

I have therefore thought it preferable to plot the results graphically, expressing the hours of combustion as abscissæ and the corresponding intensities of light as ordinates. In another final diagram are shown the curves representing the mean-results obtained on the three burners for each quality of petroleum.

One conclusion may certainly be drawn from these diagrams, namely, that the differences of illuminating power of different qualities of petroleum are much more marked in the results shown for the burners W W and K B than in those for the burner H S ; in addition, the curves obtained from the tests on this latter type of burner (H S) demonstrate, without a shadow of a doubt, *that this burner is the best adapted for interior qualities of petroleum*, or, to be more precise, for the qualities which are rich in the "closed chain," aromatic, and naphthalene derivatives, such as Galician and Roumanian oils and the mixed petroleums called "French types."

Generally the foregoing tables and diagrams show once more that those burners, which are mostly used in France, are most suitable for the use of Pensylvanian petroleum and that, when this is of a high grade, the three burners will produce approximately the same results with the same American oil.

Reverting to the tables, and examining the results for two fairly good qualities of Pensylvanian petroleum, we find :—

TABLE III. Explanation of dotted lines in Diagrams 6, 7, 8, and 9.

1.	Water White	Pensylvania, U.S.A.	
2.	Standard White	,, ,,	
3.	Light Petroleum	North America ...	
4.	Ordinary ,, ...	,, ,, ...	
5.	Illuminating Oil, de luxe ...	Galicia	
6.	,, ,, Ordinary ...	,, ...	
7.	,, ,, (Roumanian)	Roumania	
8.	,, ,, de luxe ...	Texas, U.S.A. ...	
9.	Petrole de luxe...	French Production ...	
10.	,, Ordinaire	,, ,, ...	

DIAGRAM 6. Mean of the 3 Burners W.W.—K.B.—H.S. 12″.

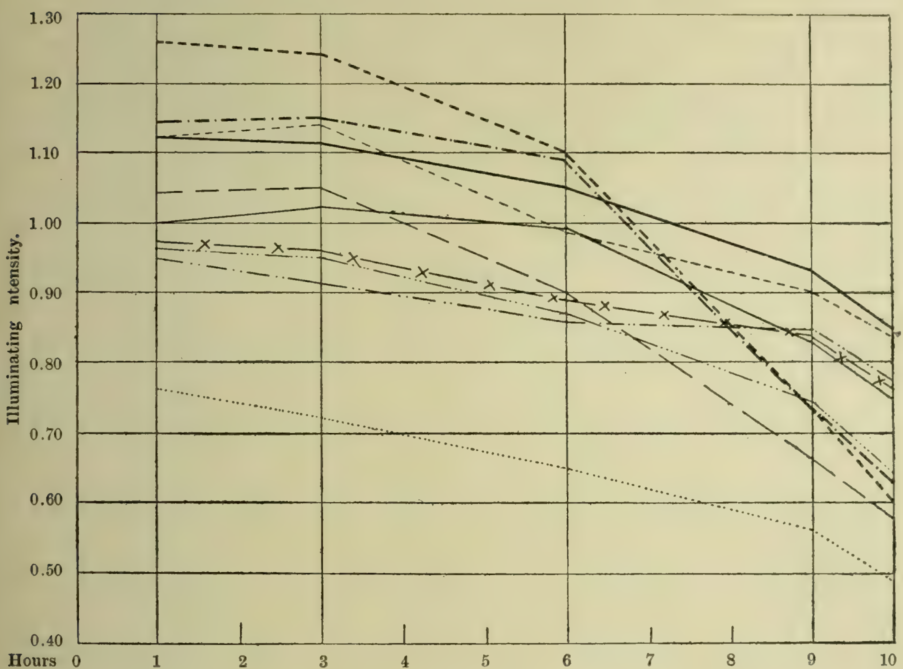


DIAGRAM 7. Burner: Kosmos W.W. 12″.

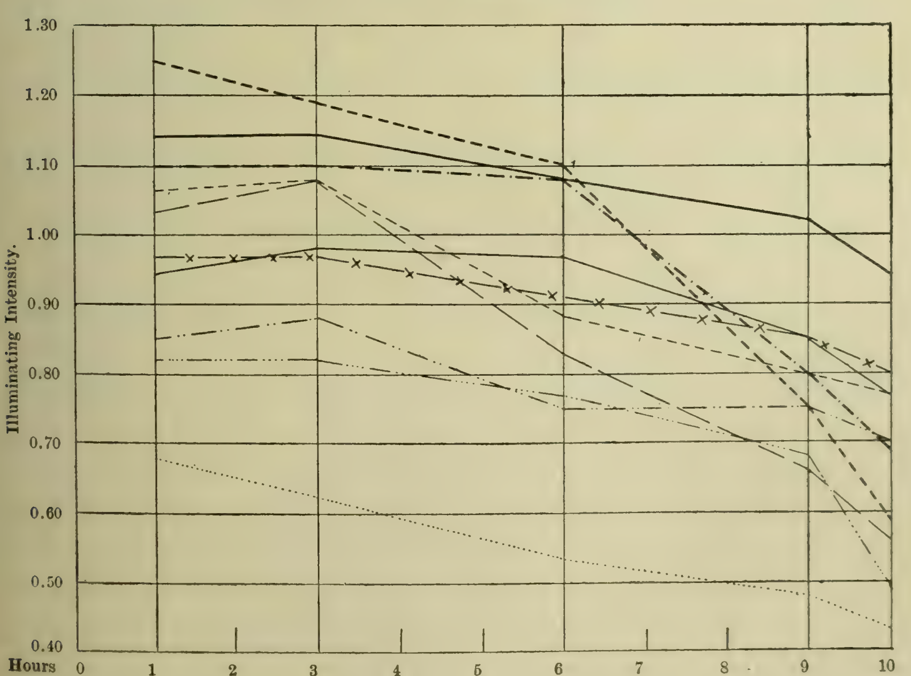


Diagram 8. Burner: Kosmos K.B 12″.

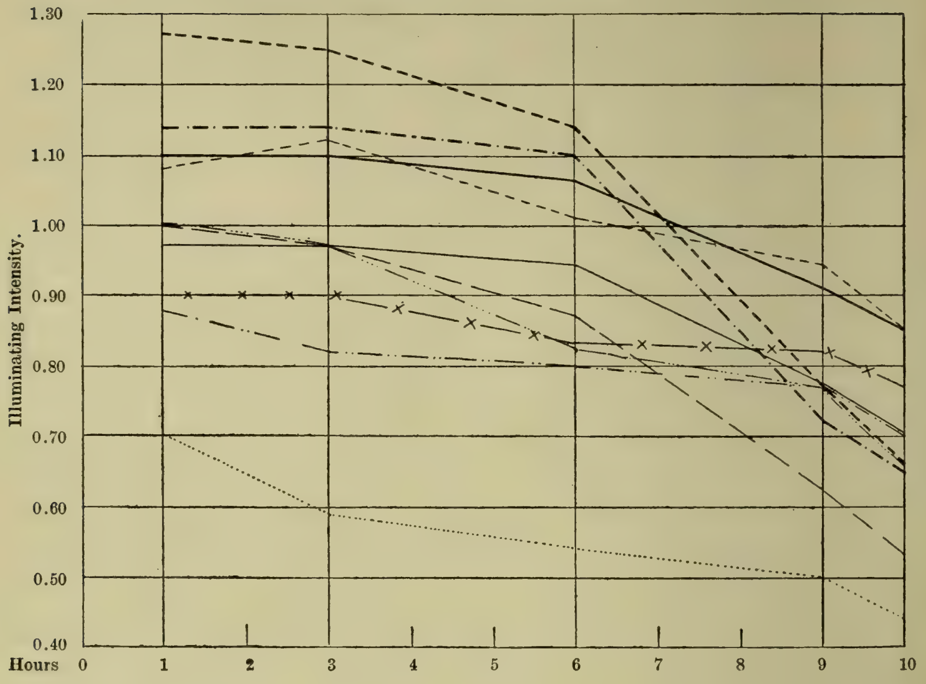
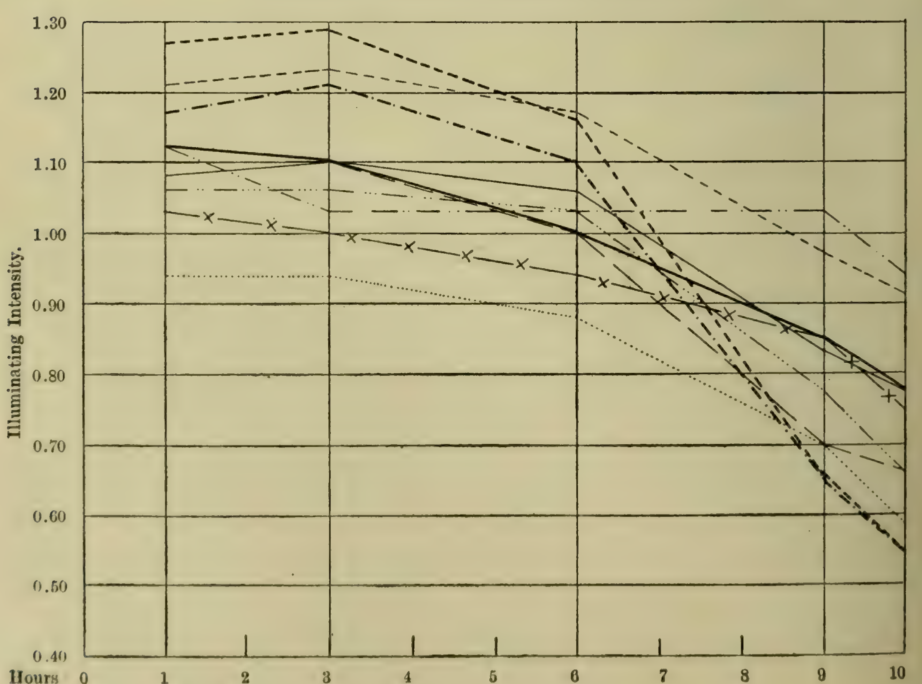


Diagram 9. Burner: Kosmos H S. 12″.



Pensylvanian Water White.

Burner.	Total output of light for 10 consecutive hours.	Mean consumption per carcel-hour.
WW	CH 10·87	gr. 35·6
KB	,, 10·90	,, 35·7
HS	,, 10·76	,, 35·3

which represents almost equal intensities with approximately identical consumption per carcel-hour in the case of three burners.

Pensylvanian Standard White.

Burner.	Total output of light for 10 consecutive hours.	Mean consumption per carcel-hour.
WW	CH 10·15	gr. 37·93
KB	,, 10·20	,, 38·35
HS	,, 10·23	,, 37·90

which shows that, while standard white comes up close to water white, as regards illuminating power, the consumption on the other hand, is considerably greater with standard white.

Applying the comparison in a similar way to qualities of Galician oil, this constancy disappears altogether, as shown by the following examples :—

Galician "Petrole de luxe."

Burner.	Total output of light for 10 consecutive hours.	Mean Consumption per Carcel Hour.
WW	CH 8·00	gr 44·12
KB	,, 8·10	,, 45·80
HS	,, 10·43	,, 37·66

Galician Ordinary.

WW	CH 5·67	gr 50·75
KB	,, 5·71	,, 50·91
HS	,, 8·57	,, 42·02

And the variations grow still more marked when we examine, for instance :

Ordinary Petroleum (French type).

WW	CH 7·66	gr 42·30
KB	,, 8·76	,, 42·14
HS	,, 9·74	,, 38·64

I believe this time to have clearly demonstrated the good qualities of Kosmos burner, model H S, which is undoubtedly the best constructed and best adapted type with which to use French qualities of petroleum (which are rich in carbon by reason of the predominant proportion of Russian and Roumanian oil contained).

What, now, are the conclusions to be drawn from these various observations, with regard to the specification and determination of the illuminating qualities of illuminating petroleum ? In my opinion, I repeat, this will always remain a very difficult subject on which to make definite suggestions.

In any case, it will be imperative to establish rigorous conditions under which comparative experiments are to be conducted and to select or define the exact type of lamp to be used in view of the considerable differences which might result from insignificant variations in detail in the construction of burners otherwise of one and the same type.

According to my view, the only definite conclusion which can be drawn is this, that it should never be said : "Petroleum A burns well and petroleum B burns badly," but that the merits of different qualities can only be adequately compared by stating the full particulars and circumstances under which such results were obtained, somewhat in this way :—

"With burner X, model Y, under such and such circumstances, with such and such chimney, wick, &c., petroleum A burns well and petroleum B badly."

I cannot terminate this treatise without expressing my thanks to my friend and co-operator, M. Madoulé, for the valuable assistance he has lent me in this investigation.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

The "Micro" Incandescent Burner.

Messrs. Thiem & Towe (Halle, Germany) are bringing out a form of burner, having an exceptionally small gas-consumption, which is termed the "Micro-gasglühlicht-brenner," and is stated to possess the reliability and solid construction of burners of the ordinary size. The entire burner costs 1·95 marks. It yields a light of 16 H.K. (horizontal) for a consumption of 19 litres (0·67 cubic feet) per hour. It is therefore anticipated that the burner will prove serviceable for the illumination of landings, small rooms, &c., where anything more than this intensity would be extravagant.

In a recent note in the *Zeitschrift für Beleuchtungswesen* the results of some tests of Dr. Lux on this mantle are given, and the following comparison with other types of burners is made :—

Flat flame burner (16 H.K.) consumes 160 litres per hour.

Round flame burner (30 H.K.) consumes 250 litres per hour.

"Normal" incandescent burner (80 H.K.) consumes 120 litres per hour.

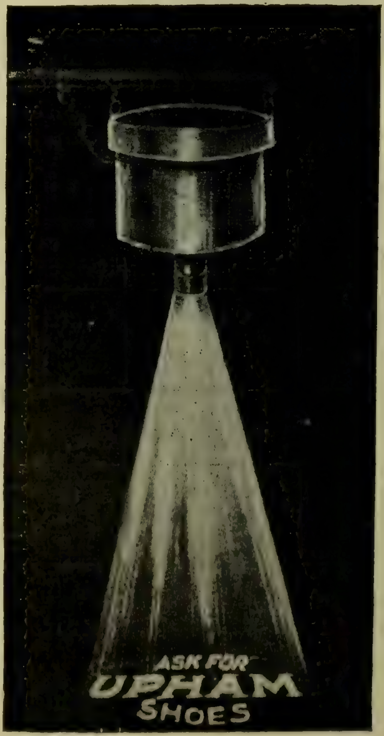
"Liliput" incandescent burner (55 H.K.) consumes 80 litres per hour.

The "Micro-gasgluhlicht" (16 H K.) consumes 19 litres per hour.

Another Interesting Electrical Sign.

One interesting type of sign which has recently come into use in the United States is shown in the illustration. It consists of a projection apparatus by which any desired motto is cast upon the pavement. In this way (always supposing that a pavement of reasonably good reflecting power is available) a luminous image is formed at the foot of pedestrians and is said to be very effectual in attracting attention. In all probability it has at least the advantage of not giving rise to any great degree of glare.

Whether the sudden appearance at the foot of the pedestrian, of an invitation to enter the shop which he is in danger of passing by will have the desired effect of making him pause and, on second thoughts, avail himself of the invitation, requires consideration. It is, however, an example of the tendency to try to arrange the advertising area beyond the display in the show-window alone.



Concealed Shop Window Lighting.

Messrs. Siemens Bros., Ltd. (Tyssen Street, Dalston, London), send us particulars of various types of fixtures for concealed window-lighting the object being invariably to concentrate the light on the goods and at the same time to screen the eye of the observer. Fig. 1 shows a form of such a rough reflector combined with special tubular tantalum lamps. Figs. 2 and 3 illustrate curved and rectangular reflectors for showcases, each capable of holding two 16- or 25-candle-power tantalum lamps. The trough type can be used either as a floor-light at the base of the window, on the same principle as the footlights on the stage, or as a toplight, in which case it is fitted above the window (preferably out of sight of the customer).

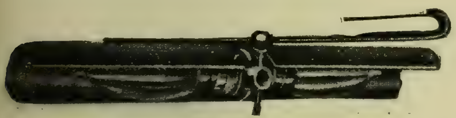


FIG. 1.

FIG. 3.

FIG. 4 may merely rest upon the top of a show-case with glass above, so as to throw the light downwards on its contents.

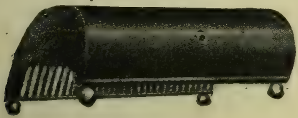


FIG. 2.

FIG. 4.

From the **Electrical Co.**, (122, Charing Cross Road, London, W.C.), we have received a catalogue dealing with sign and decorative lighting by means of flexible strips studdied with glow lamps at various intervals. Such strips can be used either in the shape of letters or to form outlines of various shapes. It has, therefore, been widely used for exhibition lighting, &c.

The **British Westinghouse Co.** send us particulars of the "ARCTURAS" flame arclamps. A special feature is the provision of an automatic arrangement which switches in an equivalent resistance in the event of the lamp failing, and thus enables several of these lamps to be run in series.

Annual Dinner of the General Electric Co.

The Annual Dinner of the General Electric Co. was held on Saturday, February 19th. The toast of "British Industries" was proposed by Mr. H. Hirst, and responded to by Sir John Taverner, the Agent-General for Victoria. A number of other representatives of the electrical industry spoke, including Dr. Railing, Mr. Morcom, and Mr. W. Duddell. The dinner passed off very successfully, and about 500 guests and members of the firm were present.

"Tantalum" Lamps for Traction Work.

The capacity of "Tantalum" Lamps to withstand vibration has, we are given to understand, been recently tested by the installation of a number of these lamps on one of the Underground Tube Railways of London. The following results have been supplied as a sample of their performance :—

Six lamps which burned for 6084 hours, are still good, and a further six lamps which have given out, burned for an average of 5,167 hours, the individual life of each lamp being as follows :—

No. 1	.. ..	7,218 hours.
No. 2	.. ..	6,600 hours.
No. 3	.. ..	4,400 hours.
No. 4	.. ..	4,314 hours.
No. 5	.. ..	4,440 hours.
No. 6	.. ..	4,032 hours.

It is stated that the lamps used were run at 2·2 Watts per candle, burning five in series, on a 600 -volt. circuit. As compared with carbon filament lamps, the amount of light is better, and there is at the same time, a considerable reduction in the current consumption.

Any further information regarding "Tantalum" lamps will be supplied by **Messrs. Siemens Brothers** Dynamo Works, Ltd., Tyssen Street, Dalston, London, N.E.

Aegma Metallic Filament Lamps. Reduction of Price.

We are informed that, owing to the increased output of "Aegma" metallic filament lamps, the Electrical Company (122–124, Charing Cross Road, W.C.) are making a substantial reduction in the list prices.

The chief reductions are as follows :—

16 C.P., 60 to 130 volt lamps	from 2/9 to 2/6
25, 32, & 50 C.P., 60 to 130 volt lamps	,, 3/- to 2/6
50 C.P., 200 to 260 volt lamps	,, 4/- to 3/6

B. T. H. "MAZDA" Metal Filament Lamps.

We are informed that in future the B. T. H. Tungsten Lamp will be known as the "Mazda" lamp, and will bear this word as a trade mark.

The new name will be used on the lamps, packing cases, cartons, &c., as rapidly as the change can be effected and in the meantime the public are notified that any lamps they may receive marked "B. T. H. Tungsten" are the same as the Mazda lamp.

Some New Types of Gas Fixtures.

In the recent number of *The Illuminating Engineer* (January, 1910, p. 55) some examples were given of recent types of electric fixtures. The illustrations on the opposite page show some corresponding modern developments in fixtures for gas lighting, particulars of which have reached us from **The Boston Consolidated Gas Co.** (24, West Street, Boston, U.S.A.).

It is interesting to notice that in these fixtures the source of light is completely screened from the eye, and the general arrangement is such as might be used for either gas or electricity.

Fig. 1 and Fig. 2 are of the hanging type. The former is an artistic dome with a single inverted burner, intended mainly for library or dining room table illumination. Fig. 2, again, utilizes a cluster of inverted burners with crystal decorations screening the source. Figs. 3 and 4 are massive types of brackets and Fig. 3, in particular, with its curved pipe is modelled on lines similar to many electric lighting types.

One feature which is of particular interest in this case, is the method employed of completely screening the bright source from the eye, and aiming, in so doing, at an artistic effect.

For office-lighting, where it is essential to concentrate light in a desired direction, and to secure efficient and economical results, scientifically designed glassware of the Holophane type is frequently combined with clusters of inverted burners in fixtures of a somewhat plainer variety.

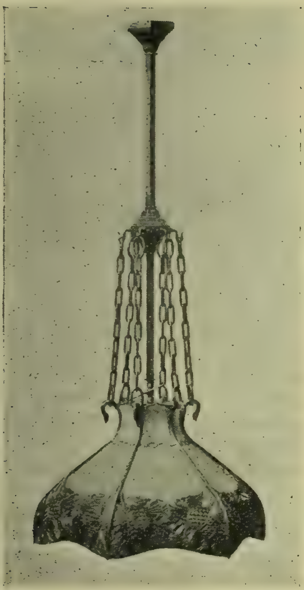


FIG. 1.

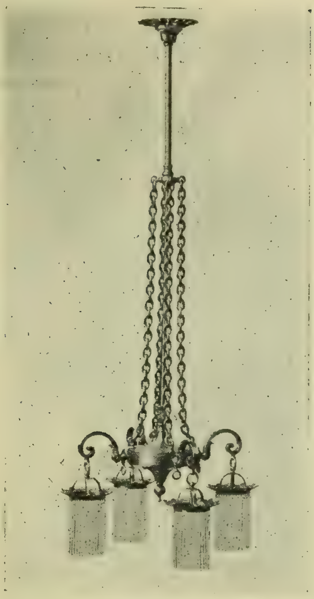


FIG. 2.

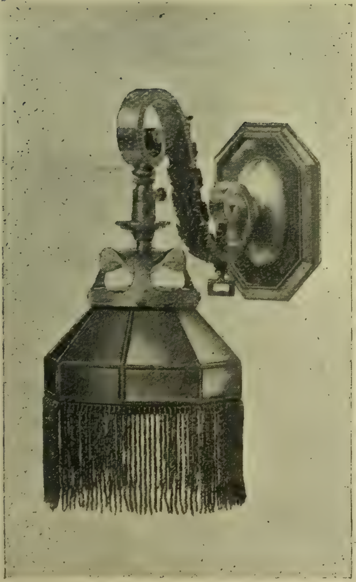


FIG. 3.

FIG. 4.

MODERN DECORATIVE GAS FIXTURES.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

There have naturally been a large number of references, too numerous to mention, to the Discussion on Glare at the last meetings of the Illuminating Engineering Society in this country. Among journals which refer to the matter we may note the *Electrician*, *Electrical Engineering*, *Electrical Times*, *&c.*, *The Journal of Gaslighting*, *Gas World*, *Gas Engineer's Magazine*, *Acetylene*, *Ironmonger's Chronicle*, *&c.*

Among editorial notes of interest we may note that in a recent number of *The Journal of Gaslighting* (Feb. 8), a suggestion is put forward that the time is ripe for the establishment of an Independent Authority on Public Lighting, to whom appeal could be made in cases of dispute. It is stated elsewhere in this journal that further sums are to be set aside for experiments on street-lighting in the City of London.

Special attention may be drawn to the series of articles by **Bernoulli** which are appearing in the *Zeitschrift für Beleuchtungswesen*, dealing with the art of illumination. Recent instalments have dealt mainly with the Illumination of Architectural Exteriors of buildings and of æsthetic interiors. The author points out that, apart from the not entirely artistic method of outlining with glow-lamps, little has been done to illuminate buildings artificially so as to show off their architectural features. The same is true as regards the display of fine carving, metal work, &c., in rooms of an artistic character. The fittings also lent themselves to artistic treatment in the past, and the author gives some illustrations of ancient lanterns, &c., for hanging outside doorways, or above staircases.

Mention should also be made of the interesting address of **Dr. E. P. Hyde,** taking a wide view of the development of illumination, which was delivered before the American Gas Institute and is reproduced in a recent number of *The American Gaslight Journal.* There are also several other papers which have been read before the Illuminating Engineering Society (U.S.A.), but have only been referred to in abstract so far. Thus **Rolph** has considered the Lighting of Bowling Alleys. He points out the vital need of placing the sources correctly so as to illuminate the pins and alley but not to shine into the eyes of those about to bowl. The illumination is also arranged to increase gradually along the alley from the starting point to a maximum where the pins are placed. In this way the attention is involuntarily directed towards the thing aimed at. **Pearson** (*Elec. Rev.*, N.Y., Feb. 5) expresses himself rather in favour of Inverted Systems of Lighting from the physiological aspect; nowadays, he says, we generally want not merely certain portions, but the whole room to be adequately illuminated.

Among matters of a more photometrical nature we may note that echoes of the discussion in Germany on the International Unit are still drifting about; several papers refer to recent contributions by **Monasch** and others on this subject.

Lastly we may mention the account of the researches of **R. G. Harris,** at Edinburgh University, on the illumination from pinhole-burners arranged symmetrically in different groups. He shows that such an illumination gradually falls as the burners are separated in general; in the case of groups of three or more, however, this was not invariably the case, apparently because the near proximity of the burners to each other affected the draught, &c.

ELECTRIC LIGHTING.

Several papers and articles have appeared dealing with Arc-lamps. Thus **Angold** recently delivered a general paper on this subject before the Association of Engineers-in-Charge (London), and this is reproduced in several of the electrical papers. The author gives some account of the principles underlying flame arcs, and makes special mention of the magazine lamp which is intended to avoid the well-known difficulty of enabling flame arc lamps to burn for a considerable while without attention. Finally he considers the respective costs of upkeep of arc-lamps and high candle-power tungsten lamps. He also points out that there is a danger that, in seeking to provide street-lighting sources with a

powerful horizontal component, a tendency to glare may be introduced.

P. A. Mossay (*Elec. Review Electrician*, Feb. 11) describes a type of arc-lamp recently produced in Germany, and described by Wedding in the *E. T. Z.* (Jan. 13), *i.e.*, the "Timar-Dreger." One essential point in connexion with this lamp is that the carbons are parallel and horizontal.

Several articles in the papers in the United States deal with street-lighting and STREET - LIGHTING FIXTURES. A description of a method of park-lighting in Newark is interesting. It consists of high candle-power tungsten sources mounted in Holophane spheres, several of which are carried on each pole. When a number of poles so equipped are used to line an avenue the resulting illumination is said to be very good and the use of globes of this nature has the effect of cutting down the intrinsic brilliancy to below that usually met with in street and outdoor illuminants.

The Electrical World also describes an application of FLAME ARC-LAMPS FOR SHOP LIGHTING that is not very generally known. This involves the installation of flame arcs above a frosted glass panel at the top of the show-window so that the diffused light floods the window and goods, but the source is not visible to the people outside. By this means, it is said, a very strong and good illumination can be secured, at a comparatively small cost.

Among articles on glow-lamps mention should be made of the series of articles in the *Zeitschrift für Beleuchtungswesen* on the MANUFACTURE OF METALLIC FILAMENTS which still continue. An interesting announcement is also made with regard to the method of grading the voltage of "Mazda" lamps in the United States. These lamps are to be marked with three voltages, such as 110, 112, and 114, corresponding with three grades of efficiency. A consumer can then select the efficiency which suits his own circuit best, and specify that either the top, middle, or lowest voltage should be the same as that on his lighting circuit.

GAS, OIL, ACETYLENE LIGHTING, &c.

The paper by **N. Macbeth**, before the American Gas Institute is included under this heading because, while devoted to the subject of illuminating engineering and the lighting of various premises, &c., it is also mainly concerned with applications of gas lighting. Besides discussing lighting problems, Mr. Macbeth gives a number of curves for different burners showing the effect of variation of pressure, &c.

D. Witt (*J. f. G.*, Jan. 29) gives a resumé of RECENT PROGRESS IN GAS-LIGHTING, including the new raising and lowering apparatus for high-pressure incandescent gas-lamps, now on trial in Germany. He states that an efficiency of 0·45 litres per H.K. (56 candles per cubic foot) has now been obtained, and that mantles in the streets commonly last 200 hours before renewal. He also gives some particulars of school-lighting on the semi-inverted system. One interesting method of lighting is the installation of well-screened sources on the left hand of the pupils, so that the light reaches them in each class-room in a direction very similar to that of daylight.

An Editorial in the last number of the American *Illuminating Engineer* deals with the criticism that more space ought to be devoted in its columns to gas lighting, pointing out that there are a very large variety of subjects besides gas lighting to be dealt with under the heading of illumination, and that while practically all gas lighting is carried out with incandescent mantles electric lighting is more complex, involving the use of many different types of lamps.

Several articles in German papers deal with the relative cost of acetylene and gas, &c., while **Gatehouse** (*Acetylene* Feb.), dwells upon its value for special research in which colour-definition is very important.

The Cause of the Offensive Odour of Mercury Lamps.

ACCORDING to *The Electrical Engineer* (August 27, 1909), a disagreeable smell is sometimes noticed in the neighbourhood of mercury vapour lamps, which has been ascribed by some to the ozonisation of the air surrounding the tube by ultra violet rays.

The true cause of the smell, however, is now thought to be excitement of the olfactory nerves, due to electric charges of the ionised air round the lamp. This, t is stated, was proved by passing the air removed from the neighbourhood of the lamp, through an earthed metal tube in which the ions were discharged. The gas issuing from the tube was perfectly odourless, but the odour returned when a glass tube was substituted for the metal one.

This suggests that the smell often noticed in the neighbourhood of static electrical machines may be due to this cause, and not to the formation of ozone as has usually been thought.

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GAS, OIL, ACETYLENE LIGHTING, &c.

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CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

ELECTRICITY · ACETYLENE · OIL · GAS

The ILLUMINATING ENGINEER

Edited by LEON GASTER

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EDITORIAL.

The Measurement of Light and Illumination.

On page 227 our readers will find an account of the discussion which took place at the meeting of the Illuminating Engineering Society, on March 15th, 1910, on the subject of the "Measurement of Light and Illumination."

A number of the best known authorities on Photometry in Great Britain were present, in several cases coming considerable distances. The thanks of the Society are due to those who added to the pleasure of the proceedings by exhibiting apparatus on this occasion.

We have once more deliberately selected for discussion a subject of a very general nature merely in order to show how wide is the ground to be covered in future debates. In considering the policy of the Society, one must remember that its main object for the present should be to attract interest of those outside; to convince the general public that it has an important place to fill and that there are before it vital questions awaiting solution.

In order to do this, we must make our meetings interesting and attractive to many who do not at present profess to be experts in the particular branch of the subject discussed. There are a number of gentlemen in this country and elsewhere, who have made a special study of photometry. They may rightly desire to have opportunities afforded of discussing some of the many crucial points on which they are conscious of present disagreement. Opportunities of this kind, the Society of course means to provide in the future. But it would be premature at the present moment to seek to settle them offhand, and we shall

deal with these problems all the more effectively when we have a little more experience behind us, and a somewhat larger membership. Those who have made a speciality of one branch of the subject of illumination can help the movement not only by initiating and carrying out researches which may subsequently be laid before the society, but also in helping to educate those who are less well informed.

For the present then, our chief aim must be, to bring home the importance of the subject with which the Society has to deal, and to lose no chance of arousing interest in influential quarters. Each new tie thus created will help us in the future. We have to "make broad pathways, letting in the Sun" first. Our efforts can be narrowed down to specific practical points afterwards.

Having drawn attention to the number of interesting matters for discussion, it is always open to us to return to them and thrash them out thoroughly on a future occasion, and this we intend doing. In the meantime, our columns are at the disposal of those who wish to communicate remarks on what has passed already. This is true, both of the subject which was discussed at our last meeting, and also of the discussion on "Glare," some further comments on which appear, in our present number, page 247.

Courses of Instruction on Illumination and Photometry.

We have several times referred to the need for courses of instruction, at technical colleges and institutions, dealing in a more thorough and practical manner with the subject of illumination.

Our feeling that more requires to be done in this respect was voiced by several members in the recent discussion of the Illuminating Engineering Society. Hitherto there has been little attempt to organize such courses dealing with the subject of illumination as a whole and not merely with some section of lighting, but we hope shortly to see developments in this direction. As regards laboratory work, it may also be said that the regular experiments provided are often of a somewhat stereotyped nature and relate to photometry only. In addition, in too many cases the apparatus provided is not of a very up-to-date character.

In fact we fancy that among the students at many technical colleges photometry has a somewhat unenviable reputation. For this the way the subject is presented is often at least partially responsible. To work in a dark room for any length of time is in itself depressing, and very often this feeling is intensified by the fact that the lighting arrangements provided are unsatisfactory.

In addition, in some technical colleges there is a tendency to lay a rather misplaced emphasis on accuracy. The importance of being able to form exact estimates of light can hardly be over-estimated, but experiments should not be entirely of a kind in which extreme exactitude in measurement is of paramount importance, and in any case the student ought to realize clearly how greatly the high order of accuracy attainable and desirable in the laboratory may be rendered unnecessary, or even useless, by considerations in practice.

What is needed at the present day is much more to bring about a recognition that, for practical purposes, the measurement of light is, after all, quite a simple and feasible process, and that even simple apparatus can often enable us to obtain sufficiently accurate results.

In this connexion we hope that those in a position to exhibit apparatus of a practical character will take full advantage of the opportunity of doing so at the next meeting of the Illuminating Engineering Society, in order to give those present a good opportunity of noting how simple a process the measurement of illumination may be.

We should, therefore, like to see instituted in the courses at colleges and institutions rather more experimental work on questions connected with illumination, as apart from the mere study of sources of light. We should also like to observe some organized attempt on their part to keep in touch with the most recent developments in photometric appliances in order that the admitted difficulties of work of this kind should not be added to by obsolete apparatus.

In many institutions, too, the facilities for testing gas or electric lighting may be admirable, but it is less usual to find adequate arrangements for both. This is naturally an unsatisfactory condition of affairs, since it is only through experiments on all illuminants that a student can become acquainted with the merits and disadvantages of the various systems of lighting in practice. Yet there is a field for each, and if the students emerging from our technical colleges are to be numbered among the future illuminating engineers they should be given an opportunity of realizing this.

A certain amount has been done, both in this country and elsewhere, in the direction of providing facilities for the study of illumination, though we cannot regard the present arrangements as at all satisfactory, and feel that much requires to be done. Even those courses of instruction in illumination which immediate necessity will probably shortly call into being can only be regarded as a temporary and preliminary method of dealing with the subject. We must now seek to form a more precise idea as to how the ideal course of illuminating engineering, as suggested by Dr. Louis Bell in his communication to the present number, should be constituted. The Illuminating Engineering Societies in this country and in the United States will, we hope, soon be able to take the initiative in this matter, and be in a position to recommend a suitable syllabus.

The Fourth Anniversary of the American 'Illuminating Engineer.'

The March number of our contemporary, the *Illuminating Engineer* of New York, marks the commencement of its fifth year of existence. We feel sure that our readers will join with us in expressing appreciation of the work that our friends in the United States have been able to do, and in wishing them even greater prosperity in the future.

That substantial results have already been achieved, however, is illustrated by the contents of the number of our contemporary to which we refer. In accordance with its custom, the journal contains a summary of the year's progress in illuminating engineering, and also, what is perhaps even more interesting, expressions of opinion on the part of managers and engineers of a wide variety of business concerns in different parts of the country.

There has been steady progress in almost every department. Gas lighting and electric light, are still feeling the effects of the introduction of inverted burners, high-pressure gas systems, and metallic filament lamps. In street lighting, in particular, there has been a steady growth of interest. Many municipalities are taking up the matter with vigour, and the recognition of the importance of this subject from the public standpoint is gaining ground; each new improvement renders it less likely that there will ever be a reversion to the old days of comparative darkness.

The opinions to which we refer, too, are not expressed by professors alone, but are also those of business men, interested in the progress of illumination from a severely practical standpoint. They are connected with many different concerns, gas and electric companies, railway companies, manufacturers of glassware, &c., and are all agreed as to the great stimulation in the lighting business that has taken place.

What we would particularly like to emphasize, is the unanimity of those

engaged in such different fields of lighting. We find, for example, gas lighting and electric lighting developing side by side, and both doing more business. It is to the interest of all makers of lighting apparatus, to take a pleasure in fostering the illuminating engineering movement by which they, as well as the public, hope to benefit.

Futile Controversy on the Relative Cheapness of Different Illuminants.

It is perhaps not altogether surprising, though it is unfortunate, that the cost alone of different systems of illumination should so frequently form the subject of controversy in the daily papers. This question of expense, which figures so largely in partisan controversy, is only one among many which determine the choice of an illuminant. This is a matter on which misrepresentation is only too easy, and even the unconscious omission of relevant details can often put quite a different complexion on a result. We ourselves have often pointed out the absurdity of a comparison in which a very powerful source of some 1,000 candle-power of one kind is compared with a very small unit of another, and in which not infrequently, the most recent development in electric lighting is compared with the most ancient in gas—or *vice versa.*

The cost of gas or electric energy, the average time which elapses before an incandescent glow lamp or a mantle requires to be renewed, the price of the lamp or mantle, &c., all these differ, and the light attributed to the different sources is often expressed in a very dubious manner. But a short while ago (Vol. II., p. 489), Prof. H. Strache of Vienna drew attention in our columns to the need for some common system of expressing the candle-power of sources.

Whatever our views regarding the correct method of comparing the light given by different sources, it must be recognized that the mere selection of the light in some particular direction must always constitute an unsatisfactory basis of comparison. The polar curves of light-distribution of different illuminants differ radically. Moreover it is becoming very customary to have resource to reflectors and globes, by which such curves can be materially modified. It is in fact becoming realised that a source of light is only in the raw condition until it has been provided with a suitable shade in order not only to screen its intrinsic brilliancy but also to direct the light where it can be usefully employed.

It is therefore obviously desirable to adopt some method of specifying candle-power which is independent of any peculiarities in the polar curve of light-distribution used, and this is a matter with which the Illuminating Engineering Society will no doubt grapple in the future.

Another feature of such discussions which is not without its amusing side is the ingenuity with which representatives of one or the other system of lighting lay hold on any apparently favourable statement by those connected with the illuminating engineering movement. In such cases stress is invariably laid on the strictly impartial attitude of the Society and the value which must be attached to the opinions of its members. When, however, an expression of opinion by the same member can be construed as unfavourable its value suffers an unaccountable depreciation.

We have never disguised our belief that controversy on this question of cost is rarely profitable. When figures are given they must be quoted with reserve, and we notice that our views are held even in quarters in which the temptation to embark on such discussions is occasionally too strong to resist.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 223) deals in this number with the Harrison Universal Photometer, which can be used either for the measurement of illumination or for testing the intensity of sources of light in the streets. He describes the most recent type of this instrument which enables measurements to be made in a horizontal, and in inclined planes, the methods of flicker or equality of brightness being available.

Mr. Trotter's article is followed by an account of the discussion on the Measurement of Light and Illumination at the last meeting of the Illuminating Engineering Society on March 15th (p. 227).

The **President, Prof. S. P. Thompson,** D.Sc., F.R.S., opened the proceedings by a brief description of a number of photometers, and showed some models illustrating the different types.

Prof. A. G. Vernon Harcourt described some tests on lighthouses which he had made for the Board of Trade, and referred to the value of a star disc grease spot photometer in tests of this kind.

Dr. J. A. Fleming made some remarks on the distinction between primary and secondary standards, and laid stress on the necessity for discovering an international standard of light based on some incandescent material.

Mr. C. C. Paterson also dealt with the question of photometric standards, and showed diagrams illustrating the agreement in photometric readings comparing incandescent lamps of various efficiencies.

Mr. A. P. Trotter dealt mainly with the first of the series of queries, and drew attention to the inadequate nature of the apparatus employed in many technical colleges and institutions.

Dr. W. E. Sumpner dealt mainly with methods of determining the mean spherical candle-power, and **Prof. J. T. Morris** gave a description of the special apparatus used at the East London Technical College for this purpose. He also expressed his approval of the grease spot photometer, if carefully made.

Mr. J. S. Dow referred to the contributions of various corresponding members, and described some experiments demonstrating how the sensitiveness of a photometer varied with the intensity of illumination. He also showed an experiment illustrating the effect of different coloured light on acuteness of vision.

Following this account on the discussion will be found the contributions of several corresponding members.

Dr. H. Stockhausen (p. 238) refers mainly to the physiological factors influencing the sensitiveness of photometrical instruments, including the effect of stray light. He also points out how photometrical measurements rarely represent exactly the experience of the eye.

Dr. Louis Bell lays stress on the need for a scientific training course in illuminating engineering (p. 242). He considers that the present attempts in this direction can only be regarded as tentative, and that the Illuminating Engineering Society should interest itself in the matter.

Dr. C. H. Sharp refers to the value of the integrating photometer, and **Mr. P. S. Millar** refers in general terms to the importance of photometry, and draws attention to the number of different papers that have recently appeared on the subject (p. 244).

Mr. F. H. Stickney (p. 245) contributes a general reply to the series of queries circulated previous to the meeting.

M. Lauriol likewise contributes some general remarks making special reference to the difficulty of comparing lights which differ in colour.

Attention may also be drawn to the contributions of **Prof. G. J. Burch** and **Dr. C. H. Williams** on the subject of 'Glare, its Causes and Effects'; Prof. Burch suggests that the method of studying the "after-image" cannot easily be applied to the quantitative determination of glare. Dr. C. H. Williams refers to the use of the "Simplex" photometer.

Dr. B. Monasch (p. 251) contributes an article on the APPLICATION OF METALLIC ELECTRODES TO ARC LAMPS. He summarizes the work that has previously been done to this field, and points out some of the misconceptions of early inventors. Proceeding, he describes some of his own experiments on electrodes composed of various metallic mixtures of magnetite and other substances.

Dr. W. Coblentz (p. 259) having completed his remarks upon incandescent solids in the last instalment of his article, now turns to the discussion of LUMINOUS FLAMES and LUMINESCENT GASES, &c. He shows that spectra of this kind are entirely different from those of incandescent solids, and illustrates his remarks by diagrams showing the distribution and energy in the bunsen flame the metallic vapour arc, &c.

On p. 265 will be found an article describing various METHODS OF DETERMINING THE MEAN SPHERICAL CANDLE-POWER OF ILLUMINANTS; in the present instalment the author deals chiefly with the globe photometer. Reference is also made to some experiments by **E. Perrine** with this apparatus. The author points out the influence on the "constant," of the position of the source of light within the globe (p. 268).

Attention may also be drawn to the illustrated article describing the ELECTRIC LIGHTING OF SEVERAL CHURCHES IN GERMANY (p. 269). This contains some information regarding some churches in which arc-lamps and other modern illuminants have recently been introduced. An interesting application of electric lighting is the use of small voltage metallic filaments for the decoration of the altar.

An article by an Engineering Correspondent on p. 273 contains some notes on the PRESENT STATE OF METALLIC FILAMENT LAMPS. The author points out that many of the early difficulties, such as excessive fragility, &c., have been largely overcome, though it is still desirable to avoid certain unfavourable conditions. Following this will be found some notes on a recent paper by **Mr. M. Macbeth** before the American Gas Institute in which the importance of illuminating engineering from the standpoint of the gas engineer is emphasized. Mr. Macbeth also lays stress on the need for some form of standard specification for gas-mantles. The Presidential Address of **Mr. H. Kendrick** (p. 279) before the Manchester District Institution of Gas Engineers is also referred to; it contains some interesting remarks on the same subject.

The paper by **Dr. C. P. Steinmetz** on the PHYSIOLOGICAL EFFECTS OF RADIATION is completed in the present number (p. 201). The author points out the analogy between the effect of chemical light on a photographic plate and that of visible light in promoting life of vegetable organisms, &c.; ultra-violet light, on the other hand, may be very injurious. Yet it is essential to observe that a distinction must be drawn between different qualities of ultra-violet light. The properties of X-rays are also referred to.

Among other articles in this number we may draw attention to that dealing with the importance of LIGHT AS AN ATTRACTION TO CUSTOMERS and the Employment of METALLIC FILAMENT LAMPS FOR STREET LIGHTING. In the first of the two articles named an account of some investigations in the United States on the influence of the lighting of shops, &c., in attracting pedestrian and vehicular traffic is given; statistics appear to show that it has a very considerable attractive power.

At the end of this number will also be found the usual REVIEW OF THE TECHNICAL PRESS (p. 285).

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p. 154, Vol. III.*)

The Harrison Photometer. — Mr. Haydn Harrison finds, as an expert in street lighting, that measurements of candle-power are generally of more importance for his purpose

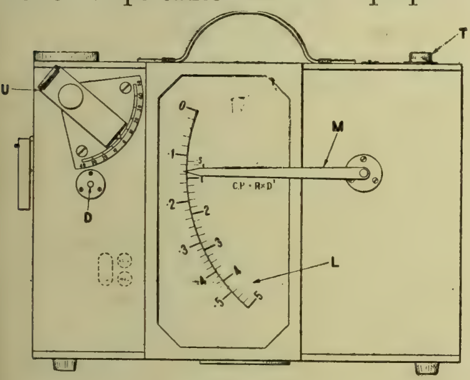

Fig. 111.
The Harrison Photometer, outside view.

than measurements of illumination, and he is content to calculate the latter from the former, taking one lamp at a time. The original form of his photometer received the light only on a screen or test plate set at an angle of 45°, but a horizontal screen has recently been added. The principle of a tilting inner screen is used, but the test plate is not perforated. The comparison is effected by the use of the flicker principle. The instrument is illustrated in Figs. 111, 112, and 113. A rather small hole A, Fig. 112, in the top of the instruments allows the screen B to be seen when viewed vertically. The screen B is inclined at 45°, and consists of a disc from which two sectors of 90° have been cut away. The disc is free to revolve on a spindle, and is set spinning by a current of air acting on the vanes C. The air is blown through the tube D by means of an indiarubber ball. A mirror E is set at such an angle that the tilting screen N may be seen through the hole A. The screen N may be illuminated by a small lamp F, or a large lamp G. When the disc B is set spinning alternate views of the disc and of the screen N are seen. The intention of this arrangement is that when the brilliance of the screens is unequal there is an appearance of flicker, but when the screen N is suitably tilted and the brilliance of each screen is the same, the flicker disappears. When the light to be measured is of about the same colour as that of the little lamp in the photometer, there is no advantage over the use of a perforated screen or Conroy method, and there are some disadvantages. But when the lights are of different colours it is possible still to obtain a disappearance of the flicker. It is supposed that the brilliancies of the two screens are then of the same value. Some doubt has been thrown on this, and until I have

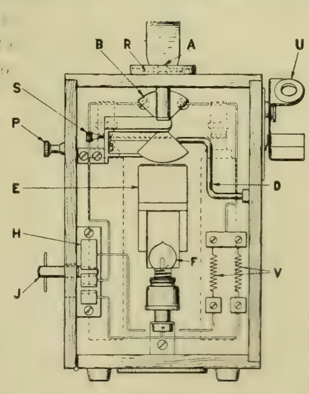

Fig. 112.
The Harrison Photometer, end view of interior.

had opportunity of practical experience with the flicker photometer, I am not prepared to express an opinion on its merits. But there is no doubt that

for ordinary ranges of colour and an accuracy of plus or minus 4 or 5 per cent. the flicker principle is very convenient. Some little knack is necessary to spin the disc at the right speed. This varies with the brightness. With strong light the speed must be slower. At too high a speed considerable change may be made in the brilliancies of the two screens without producing flicker. The knack may be learned in a few minutes, and little or no photometric experience is necessary. A rather important feature in connection with Mr. Haydn Harrison's work is the demonstration of the comparison of different kinds of illumination to the members of municipal governing bodies. Such a person would be able to satisfy himself of the absence of flicker if the

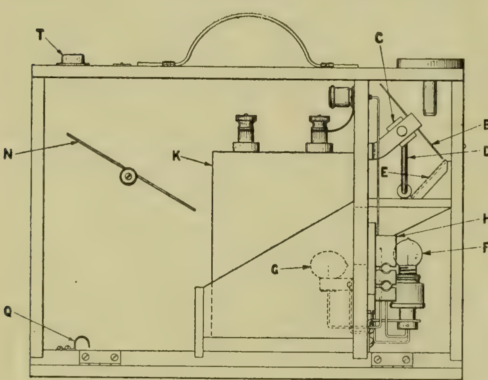

FIG. 113.
The Harrison Photometer, side view of interior.

instrument had been set for him, and he would imagine that he was somewhat the wiser. But he might be troubled with the colour difference of an ordinary photometer with white screens.

For candle-power measurements in street work it is not necessary to deal with small illuminations, and these are avoided also by setting the disc at 45° instead of horizontally. The scale L of this photometer is not, therefore, intended for low readings. The pointer M serves also as a handle for moving the screen N. A knob P is provided for holding the end of a measuring tape. Either of the two lamps may be lighted by inserting the plug J into the two-way block H, thus securing one of the best kinds of contact. When not in use, the plug is kept in the clip Q. The accumulator K is contained in the instrument, no loose wires are employed, and the connections between the lamps and the accumulator are permanent.

A level T is fixed on the top of the instrument, and for cases where the lamp to be measured is not directly facing the 45° screen B a clinometer U is provided. This consists of a lens which throws an image of the lamp on to a mark on a screen. Both lens and screen can turn on a horizontal axis, and an index shows the angle at which they point. Resistances V enable the lamps to be adjusted for candle-power.

When a considerable number of lamps are in view it is not difficult, as a rule, to measure the combined illumination on a horizontal screen without obstructing any important lights, but the converse, the measurement of the candle-power of each, and the calculation of the combined illumination would not only be very tedious but would be inaccurate if, as in the case of interior illumination, there is much reflected light. For such purposes the screen inclined at 45° must be given up, and Mr. Harrison has provided a horizontal screen surrounding the hole A. When this is employed he abandons the use of the flicker principle, and the photometer becomes a perforated screen instrument, with a vertical view; the screen N being seen by reflection in the mirror E. The sector disc B is clamped by the screw S to give a clear view between the sectors.

(*To be continued*).

The Value of Light as a Means of Attracting Traffic and Customers.

The fact that the lighting of a shop is an important factor in attracting customers is now very generally appreciated. The use of light by the salesman may be said to serve a double purpose, *firstly*, to attract the customer, and *secondly* to enable him to see what is on sale when he arrives. It is part of the work of the illuminating engineer to see that these two requirements are so met as not to conflict with one another.

While this fact is fully realised, however, there are not on record many experiments deliberately designed to test the effect of light in this way. It may, therefore, be of interest to refer to an account by Mr. J. M. Conelly, in our contemporary *The Illuminating Engineer* of New York (January, 1910), dealing with some data collected by Mr. H. L. Doherty, the president of the Denver Gas and Electric Co. In this city the application of light to attract custom has received much study, and the Gas & Electric Co. recently organized a system of counting the number of pedestrians and people carried by vehicles passing along various streets after dark. The result of these investigations seems to be rather striking. They are claimed to demonstrate that the evening flow of traffic and pedestrians is governed mainly by the window and street-illumination. In addition it appeared that the attracting power of certain well-lighted shops was directly dependent upon the amount of light utilized, although some arrangements were naturally more attractive than others.

The effectiveness of the lighting could be roughly expressed as the number of foot passengers per candle-power. In most cases this figure varied between 0·78 and 1·27, but in one instance, when the light seemed to have an unusually effective attracting power, there were more than three passers-by per candle.

In general, it is suggested, the crowds come for the lights. The worth of a business site is mainly dependent upon the number of passers-by during business hours, and this again appears to be largely influenced by the system of lighting. Passers-by of all kinds add to the value of a premises from the advertising standpoint; but pedestrians are naturally more valuable than passengers on tramcars, &c., since the latter can only give a fleeting glance into the windows, while the former may remain to examine their contents. It must be borne in mind that somewhat different measures are needed to attract these two classes. A sign that catches the eye of a man driving a vehicle may not answer the purpose of attracting and keeping the attention of the pedestrian. When in addition we recall that it is obviously desirable to avoid any kind of attracting device which, owing to excessive brightness or other cause, is offensive to the eyes of people who have arrived with the object of observing the contents of the windows, it is evident that there is room for a considerable amount of psychological study in shop- and sign-lighting.

It seems to be recognized that the salesman who is impressed by the value of unduly powerful lights outside his shop has in his mind the analogy of the moth and the candle, and believes they attract custom. But we must also recognize that light so used is in the "raw" condition, and consider how to arrange suitable semi-transparent screens or illuminated devices, to be placed round such sources, which, while cutting down their intrinsic brilliancy below the objectionable value, still constitute sufficiently prominent and attractive objects.

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Measurement of Light and Illumination.

THE next meeting of the Illuminating Engineering Society will take place on Thursday, April 14th, 1910, at 8 p.m., at the house of the Royal Society of Arts (John Street, Adelphi, London, W.), when the discussion on "The Measurement of Light and Illumination," (*Illustrated*), will be resumed.

In order to make the discussion as complete as possible it is again hoped that foreign members and others who are unable to be present, will send written contributions which should *preferably* be in the hands of the Hon. Secretary (Mr. L. Gaster, 32, Victoria Street, London, S.W.) by April 11th ; but we will also welcome communications at any time from members who find themselves unable to send them in by the above date.

The following series of queries on the subject was prepared and published in the March number of *The Illuminating Engineer* in order to suggest a few points on which discussion would be valuable. Naturally this list is only suggestive, and discussion will also be welcomed on other recent developments in the subject.

It is again hoped to make the exhibit of different forms of apparatus a special feature of the next meeting.

At the last meeting of the Society attention was mainly devoted to the underlying principles of the subject. The more practical applications, such as the measurement of illumination in streets, factories, libraries, &c. (see Queries 6, 7, 8), will be chiefly discussed at the next meeting of the Society to be held on April 14th.

Members and others desiring to participate in the discussion are invited to send in their names to the Hon. Secretary previous to the meeting.

List of Queries :—

1. Are the courses of instruction and experimental facilities at technical colleges and scientific institutions for the study of photometry adequate, and what changes are desirable in the existing methods to suit modern requirements ?

2. What is the maximum sensitiveness (*i.e.* the smallest percentage change of illumination perceptible to the eye) at present obtainable from photometrical instruments in the laboratory ? How should this sensitiveness be tested and expressed, and to what extent does it differ in the case of different individuals ? In what directions may improvements be anticipated in the future ?

3. What are the best modern methods of obtaining the polar curves of light-distribution and of measuring the mean spherical candle-power of different sources, and what possibilities are there of simplifying and improving such processes in the future ? What are the best methods of deriving the mean spherical or mean hemispherical candle-power from such curves in the case of all illuminants ?

4. As it is desirable that there should be international agreement on the subject of the commonly accepted method of measuring and expressing the intensity of illuminants of all kinds in order that results referring to different sources may be comparable one with another, on what basis should such comparisons of illuminating power be made, and what information should be included in a report of tests of this nature ? Is it desirable that all lights should be compared in terms of Mean Spherical candle-power ?

5. What is the best method of comparing the intensity of modern sources of light which differ in colour ?

6. What are the main qualifications of an illumination-photometer for practical work ? With what degree of accuracy can the illumination in streets and buildings be measured, and what limits of accuracy should at present be permissible ?

7. Discussion of the exact value and significance to be attached to photometrical measurements in streets, and buildings, and the possibility of framing and carrying out a specification relating to the conditions of illumination in such cases. To what authority is it desirable that dispute regarding such specifications and photometrical measurements should be eventually referred ?

8. What are the best methods of studying and measuring daylight illumination ?

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Measurement of Light and Illumination.*

(Discussion at a meeting of the Society held at the House of the Royal Society of Arts (London) on Tuesday, March 15th, 1910.)

A DISCUSSION on the above subject took place at a meeting of the Illuminating Engineering Society held at the House of the Royal Society of Arts (London, W.), at 8 P.M. on Tuesday, March 15th, the President, Prof. S. P. Thompson, D.Sc., F. R.S., being in the chair. As on the previous occasion, a list of queries bearing on a few points of special interest had been prepared and circulated previous to the meeting. This list of queries was published in the last number of *The Illuminating Engineer*,† and will be found reproduced on the page opposite.

The President called on the Hon. Secretary to read the minutes of the last meeting, and subsequently to read again the list of names of gentlemen submitted for membership at the last meeting of the Society, who would now formally become members.‡ This list was duly read and the gentlemen in question were declared members of the Society. The Hon. Secretary next proceeded to read out the names of the following gentlemen, which had been submitted to, and approved by, the Council since the last meeting on Feb. 15th :—

Vice-Presidents :—Mr. W. M. Mordey, M. Violle (Paris) ; *Ordinary Members :* Mr. G. R. Barham, Mr. H. W. Jones, Mr. J. D. Knight, Dr. A. Levy, Mr. T. E. Slaughter, Mr. R. F. Venner ; *Corresponding Members :* Dr. F. Schanz (Dresden).

The President said that the discussion that evening would be devoted to methods rather than results. It was the intention that at the meeting a month hence they should discuss results rather than methods. He had been asked by some members of the Council to open the discussion by making a few remarks upon some very simple and rough pieces of apparatus which he had used from time to time to illustrate the elementary principles of photometry.

The President then explained some apparatus which he had had occasion to make, in connexion with the meeting of the British Association meeting at York three years ago, in order to show approximately and quantitatively the value of different sources of illumination. In this he used one of Prof. Fleming's 10 candle-power standard lamps. The photometer head consisted of two pieces of looking glass at 45°, one reflecting the light from the standard on to a piece of ground glass, and the other reflecting the light from a lamp to be tested on to the other half of the ground glass. By shifting the lights an equality of illumination was obtained on the two halves of the ground glass, and the candle-power was read off on a scale. The art of photometry consisted in judging when equality was reached—a difficulty which was increased owing to the fact that the light from some lamps was redder than in the case of others ; for instance, the Fleming standard was redder than a metal filament lamp.

Dealing with the question of standards the President mentioned that the Hefner candle was the unit of light in use in Germany ; the intensity of this in relation to the English candle was in the proportion of 9 to 10. As a standard the English "candle" was found to be too unreliable, and

* Attention may be drawn to an article on this subject which appeared in *The Illuminating Engineer*, June, 1908, p. 498, and in which a number of recent photometrical instruments were described.

† *The Illuminating Engineer*, Lond., March, 1910, p. 168.

‡ See *The Illuminating Engineer*, Lond., March, 1910, p. 191.

had been abandoned a long time ago. Various suggestions had been made regarding the replacement of this "standard" by something more accurate, and the best of them so far was the Harcourt pentane lamp, which had now received wide recognition, and had been officially adopted by the gas referees.

The President then went on to describe briefly a number of other photometers such as the Ritchie wedge* and the Rumford shadow instrument.† The latter, he said, answered very well, as long as all extraneous light was shut off and the illuminated surface was viewed against a dark background. The two shadows should also be adjusted so as just to touch each other and not to overlap.

Another piece of apparatus exhibited was the type of grid photometer‡ due to Mr. Trotter. In this instrument one inclined white surface was looked at through slits in another, balance being obtained when the central slits apparently disappeared.

Another very excellent photometer, much better than many in use at the present day, consisted of a couple of blocks of paraffin wax with a tinfoil or silver-foil partition between them, making an opaque division.§ Each of the halves lighted up according to the amount of light thrown upon it and it was thus possible to find a position in which the two sides appeared equally bright.

Turning next to the grease spot photometer,‖ the President recommended that such instruments should not be made of spots of grease. The best method was to take a piece of thin paper and place it between two pieces of cardboard, each pierced with a round hole. Like every other grease spot, however, it did not actually disappear, and one's object should be to try and place the screen in such a position that on looking on *both* sides at once by means of mirrors, the contrast between the spot and its surroundings appeared the same in each case. Personally, he did not like the grease spot screen, but there was one piece of apparatus which represented a beautiful and successful optical attempt to create the qualities of an ideal Bunsen grease spot. This was known as the Lummer-Brodhun photometer, by the aid of which a much more perfect idea of equality could be obtained.

Finally, the President referred to the Flicker photometer, which was supposed to be—he did not say it was—more satisfactory than any other in dealing with lights which were not of the same colour. He exhibited a model device in which any want of equality of the two lights was shown by a flicker on an exposed piece of ground glass.

Prof. A. G. Vernon-Harcourt said that the comparison of lights of various colours had been attempted in different ways. One plan of Sir William Abney's which gave very good results, depended on a rapid movement of the disk-holder, corresponding to some extent with the flicker photometer; by presenting at short intervals the bluer light and the redder light it was possible to form a judgment of the relative luminosity of the two sides, much better than could be formed by a gradual adjustment of the distances. He had tried various methods, and that which he had found to be the best was the Leeson disc, which was in use forty years ago. It was better than the grease spot or plain disk, and consisted of two surfaces of the same translucent paper with a piece of opaque paper in between in which a hole was cut. This hole was cut of a star shape, with very deep serrated edges. Some years ago he was asked by the Board of Trade to assist in estimating the amount of light given by lighthouses with different illuminants. There were three experimental lighthouses set up on the South Foreland. One contained an oil lamp of the Argand type with many concentric wicks, another used a similar gas burner fed with gas made from oil, and in the third was an electric arc. For the measurement of these lights there were set up huts at different distances.

* *Illuminating Engineer*, vol. ii. 1909, p. 7.
† *Illuminating Engineer*, vol. i. 1908, p. 887.
‡ *Illuminating Engineer*, vol. ii. 1909, p. 583.
§ *Illuminating Engineer*, vol. ii. 1909, p. 442.
‖ *Illuminating Engineer*, vol. i. 1908, pp. 151, 977.

The lighthouses were placed in a straight line, about 30 or 40 yards from each other, and along a line perpendicular to this were stationed huts, half a mile, a mile, and two miles away. For the purpose of measurement a one-candle flame-lamp was used at a distance of about the width of the hut, which was 10 or 12 ft., while the beams from the lighthouses were directed through an open window upon the photoped of the photometer. The lights were very different in colour from the one-candle flame, especially the arc light, which threatened to cause difficulty in the measurements. But the faintness of the illumination greatly lessened the difficulty. Many of those present must have observed that when walking through a garden in the dusk, while the forms of leaves and flowers were still discernible, differences of colour had almost disappeared, and the leaves and petals of the scarlet geranium seemed much alike.

For the measurement of illuminants not through lenses and at less distances the star disc, placed in a movable holder, was used. In order to ascertain how far personal judgment could be relied upon he enlisted the services of a number of Trinity House men. They knew nothing whatever about photometry, and he had to instruct them what to do. His instruction was that they would see on one side a pale blue star on a pink background, and on the other side a pink star on a pale blue background; that they were not to think of difference of colour or brightness, but to move the holder backwards and forwards until they found a position in which the two stars stood out with the least distinctness on their respective backgrounds. The result was that one man after another gave very nearly the same reading, the observations being repeated many times, and the readings being made and silently recorded by another man.

Dr. J. A. Fleming, F.R.S., dealing with the question of primary and secondary standards of light, said that, in spite of the large amount of work that had been done on this subject he thought it could hardly even now be considered to be in a satisfactory condition. At the present time there were three national standards, all flame standards, viz., the Pentane, the Hefner, and the Bougie-decimale, or Carcel. A considerable amount of labour had been expended in determining the ratio of these standards, but they all laboured under the disadvantage that their light varied considerably with atmospheric pressure, moisture, carbonic acid, and other conditions of usage. Hence many correcting factors were necessary. Now the curious fact was that none of these variations had been noticed until electric lamp photometry had been carefully established, and it had been found necessary to employ standard electric glow-lamps such as his (Dr. Fleming's) large bulb electric lamps to determine how much a flame standard such as the Pentane was affected by atmospheric changes. Yet when this was done the electric glow-lamps were thrown on one side, and the Pentane declared to be the standard of illumination.

In his opinion enough consideration had not been given to the platinum standard suggested by M. Violle as a practical standard of light. It was true that there were great difficulties connected with its use, but national physical laboratories existed for the purpose of dealing with difficult experimental problems. At the present time, by means of the electric induction furnace a mass of platinum could be heated to its melting point far more easily than by the oxyhydrogen blowpipe, and it seemed to him that the ideal primary standard of light could only be realized by the radiation from a unit of area of a pure metal like platinum at its melting point. He hoped it was not too late for this matter to be reconsidered as the disadvantages of a flame standard for a primary standard of light were very considerable.

As regards secondary standards he ventured to think, after fifteen years' experience of them, that no better type existed than the large bulb electric glow-lamps which he (Dr. Fleming) made known in 1902 in a paper read to the Institution of Electrical Engineers. One

of these standards had been in use in his own laboratory for fifteen years, and there was no evidence that in that time it had altered its candle-power corresponding to a standard current by as much as half of 1 per cent. These large bulb standards had been repeatedly compared with the Reichsanstalt, and with our National Physical Laboratory standards, and no evidence of any permanent variation had been found in them.

He thought that both for the primary and for the secondary standards of light electric incandescent standards were in every way preferable to flame standards, and he hoped that in time this might come to be the official opinion, and that the influence of the Illuminating Engineering Society might be exerted in this direction. By so doing it might be possible to secure a single physical primary standard of light, accepted as the international standard, in place of the three different flame standards now in use. Such an international standard should define the international candle and also act as a primary standard of light with which other standards could be compared, just as in the case of the international electric units now universally accepted.

Mr. A. P. Trotter said that he would begin with the first of the queries which had been suggested for discussion: "Are the courses of instruction and experimental facilities at technical colleges and scientific institutions for the study of photometry adequate, and what changes are desirable in the existing methods to suit modern requirements?" Some two and a half years ago he had begun a series of articles on illumination, and in preparing for these he wished to acquaint himself with modern practice, and had visited the photometric test rooms of several large engineering works, of lamp manufacturers, and of the laboratories of a few technical colleges. He was amazed at the antiquated and limited apparatus which he found at certain teaching laboratories. The teaching of photometry consisted of two different parts, the science and the art. The former could be learnt by lectures and reading, and the latter by laboratory work. The President had alluded to this distinction. The proper course appeared to be, in this, as in other subjects, first to lay a sound foundation of science. The theory was very easy, but it gave large scope for mathematical treatment if necessary. The next thing was to learn the art of using the apparatus with intelligence and accuracy, and afterwards it might be possible to earn money by practising the art.

Photometry seemed to him to be in danger of falling between the two stools of physics and of engineering. He held that the teaching of engineering should be based upon physics, and that it should really consist of specialized physics. Even as a branch of physics photometry seemed to be most lamentably treated. He knew little of the courses of study at the colleges, he could judge mainly from the apparatus in the laboratories and from the text-books. He did not know of a single text-book in the English language, including even the translation of Palaz, and Stine's excellent book, in which the Bunsen photometer was not inaccurately described. In some it was accurately described also, which produced confusion. All these text-books ignored the use of proper screens, which was a vital part of the art of photometry, though it could be omitted in the scientific treatment of the subject. The apparatus which he had found in teaching laboratories consisted either of old Bunsen photometers twenty or thirty years old, suitable in their time for testing gas, or they went to the other extreme, and only had most expensive and highly accurate equipment, suitable for research, but unfitted for engineering purposes. Again in nearly all laboratories the old-fashioned method of fixing a standard lamp at one end of a bar, the lamp to be measured at the other, and a photometer moving between, was used; and the principle of a working lamp, and the substitution method in which a standard was placed in the position to be occupied by the lamp to be measured, was not employed.

He believed that the scientific principles of photometry should be

illustrated by simple models of the historical types, and he exhibited to the meeting a set of such models comprising two kinds of Ritchie, the Thompson-Starling, the Conroy, the Bunsen, and the slot or perforated screen pattern. With some of these simple home-made models, work could be done with a precision of one-half of one per cent.

which could be used for commercial purposes. As to the suggestion of following up the work of Violle and Petavel this was contemplated, but he was afraid there was one point which ruled out the possibility or the usefulness of the Violle standard, and that was the colour, even supposing it were possible to reproduce it and make an accurate standard of it. Molten

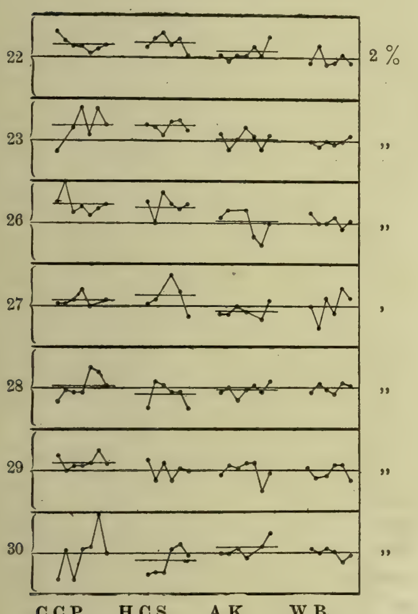

Fig. 1.—3·5 Watts per C.P. Standards compared with 4 Watts per C.P. Standards.

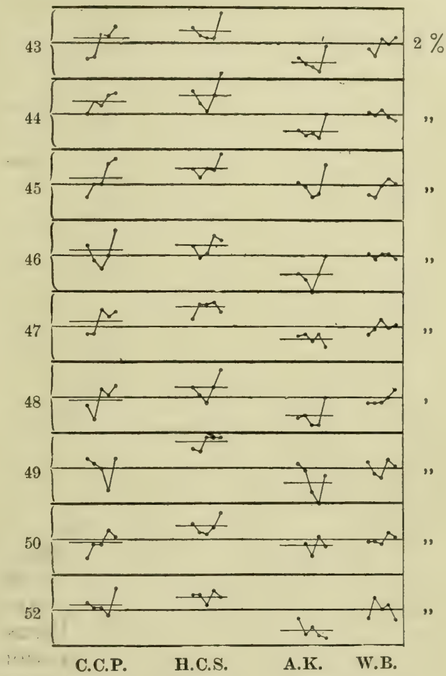

Fig. 2.—3·1 Watts per C.P. Standards compared with 4 Watts per C.P. Standards.

Diagrams showing the results of the photometric comparison by four observers of three sets of sub-standards differing from each other in efficiency. Each dot represents one day's observation on a lamp by one observer. The numbers of the lamps are given in the left hand column, and the initials of the observers at the bottom of the diagram (*Mr. C. C. Paterson*).

Mr. C. C. Paterson (National Physical Laboratory) speaking in reference to Prof. Fleming's remarks, thought he had run down the pentane standard rather severely. In spite of certain drawbacks it was serving very well at the present time as a standard. It was possible with care, and using the lamp in the right way, to reproduce the unit of candle-power from the pentane standard to an accuracy of plus or minus 0·2 per cent—probably plus or minus 0·1 per cent. They at the National Physical Laboratories were faced with the practical question of getting a unit platinum, as far as could be seen, gave a very red light, much redder than the pentane lamp, and he thought this must rule it out.

The President: Is it any worse than the Hefner?

Mr. Paterson said it appeared to be, although he had not yet made actual experiments, and the Hefner was worse than the pentane. With regard to Dr. Fleming's comparison of the electric lamp and the millimetre scale, it was necessary to compare the scale against something absolute to make sure it was correct. In the same way the

electric lamp was not a standard until it had been compared against something absolute. He was second to none in his admiration of the usefulness of the electric sub-standard, but its value had to be first determined in terms of some other standard.

On the question of the colour problem, he thought that this was a physiological one. Whether it was due to differences in the sensitiveness of the retina or the colour of the pigment in the retina, one man saw red brighter than blue, while another man saw vice versa. Therefore, surely the colour problem must be based fundamentally on some form of average value, *i.e.*, they must get an "eye" which can be considered as the "average eye." He did not know how this could be done on a really wide scale, but he had initiated an investigation with the object of seeing where we stood in the matter. He had taken a number of sets of electric sub-standards, each set differing slightly from the next in the colour of the light emitted. Starting from 4 or 4·5 watts per candle the sets of sub-standards went in steps of about 0·5 watts per candle down to 1·5. Each colour difference interval was very slight, and it was possible for each observer to obtain an accurate value of any set in terms of the one before, and so determine by a "cascade" method, the equivalent of the pentane unit in a much whiter light. There were five or six observers on the work, all of whom had normal sight by the ordinary colour tests. He was not able to say as yet what order of agreement would obtain between the various observers, but the method promised well, and was giving valuable information as to the accuracy obtainable with various degrees of colour difference. It appeared to him that if there were observers comparing lamps in this way at the National Laboratories in Europe and America it might be possible from the average result to achieve an accurate determination of whiter light in terms of say the Pentane and Hefner units, and so put the question of high efficiency sub-standards on a satisfactory basis. It should also prove of value in supplying standards for use in the testing of gas mantles, arc-lamps, and other high efficiency sources where the colour difference was at present a difficulty. The speaker illustrated his remarks by two slides showing the kind of results which were being obtained in the investigation (see p. 231).

Dr. W. E. Sumpner spoke on the question of the best method of obtaining mean spherical candle-power.

The question divided itself in two parts, viz., the testing of glow-lamps, and the testing of arc-lamps. In relation to these the general law of distribution of light had been worked out theoretically by Dr. Fleming for the glow-lamp, and by Mr. Trotter for the arc-lamp, but practically it was a difficult and tedious matter to get the actual mean spherical candle-power. It was comparatively easy in relation to glow-lamps and he thought the best way to define the candle-power of a glow-lamp was by its candle-power in the direction at right angles to the filament. This test was easy to make, and from the value obtained it was easy to deduce the spherical candle-power by multiplying by a factor, about 0·8, which was almost the same for all glow-lamps.

As regards the light of arc-lamps it was a different matter altogether. Here they had to deal with a distribution which varied in a very complicated sort of way, and also they had to measure a quantity which was not constant in itself. There were very few arc-lamps that were constant for more than a second, and although elaborate methods had been devised for measuring the candle-power of arc-lamps in different directions, he did not think many people actually worked them out, because the process was tedious and complicated, and the result rarely if ever accurate. He himself had tried to get the mean spherical candle-power some years ago by a method analogous to that of the Ulbricht globe. This was a large globe with a white internal surface, and by its use it was possible to get the mean spherical candle-power from a single test. But he saw no particular need for the elaborateness of this globe. At all events, before he heard

of this method he had tried a similar one.

In all these photometers they utilized the principle of light being reflected from a white matt surface. There was no reason why this principle should not be used twice over in a photometric test. He had used it previously, not like Ulbricht by surrounding the light with a globe, but in a simpler manner by means of a surface of white drawing paper, which gave a diffused light, and which was used in such a way that the light received from that paper in the photometer was a measure of the mean spherical candle-power of the arc-lamp. In a photometer room with black walls he had the arc lamp placed at a certain height above the floor, and at a fixed distance from a vertical strip of paper. The width of this strip varied with the height, and was so shaped and fixed in reference to the arc that each horizontal element of the sheet added to the light sent to the photometer the proper proportion to make the total light received a measure of the mean spherical candle-power. The proper shape for the paper sheet was independent of the polar distribution of the light tested and merely depended on the position of the arc with reference to the sheet and on the line of the photometer bench. The idea was to alter the width of the sheet at different heights to compensate for the more or less favourable positions of different parts of the sheet. The object was to get an easy method employing simply a sheet of white paper cut in a special way once for all, and placed in fixed relation to the arc-lamp and the photometer bench. He managed to get good results in spite of certain difficulties. Perhaps some simple modification of it would suggest itself to others. The determination of mean spherical candle-power was important but if it was to be done commercially it must be done by a single test.

Mr. W. J. Liberty (Lighting Inspector to the Corporation of London) said that he was one of those who was looking forward with great interest to the prospects of international standardization in photometry just as we had already taken an important step toward the International Unit of Light; he hoped that we might soon have one single standard, and no longer the "Pentane" standard for Great Britain and America, the "Hefner" for Germany, and the Carcel or Bougie Decimale for France. At present there was a tendency for an authority to cast doubt on the results of every other observer merely because he used a type of instrument which commended itself to him personally, and he thought that a different conclusion might have been arrived at, had a different photometer been used.

Mr. Liberty added that he thought one of the best types of photometers was undoubtedly the flicker, because it could be worked without the question of colour proving so troublesome; he was awaiting with interest the result of researches on this question at the National Physical Laboratory. In any case he thought that if the Illuminating Engineering Society could succeed in bringing people together, and in getting an agreement on a common method of testing that would commend itself to all parties, they would have done a magnificent piece of work.

Prof. J. T. Morris said that, after having had prolonged experience with the grease spot, flicker, Lummer Brodhun, and other photometers, he had come to the conclusion that the grease spot instrument was remarkably satisfactory; at any rate he could secure as good results with it as with the Lummer Brodhun instrument. Of course the grease spot must be really well made; in some cases as many as one to two dozen trials would have to be made before a spot was obtained yielding high sensitiveness in the photometer. He preferred a small spot, secured by allowing a single drop of candle grease to fall on a sheet of paper of suitable quality, the surplus grease being peeled off while still hot, and the opposite side of the paper then being slightly heated over a bunsen burner. A screen made in this way was quite as sensitive as a Lummer Brodhun photometer, and much less expensive.

Regarding the testing of high power lamps, he had some diagrams of the

polar curves of incandescent gas and electric lamps, showing the amount of variation found in the candle-power at different angles taken at different times as determined by him in 1908.* It was of little use to measure the candle-power in different directions, and then, having done so, take out the results. One had to make a number of observations and take the mean of them.

Prof. Morris showed a number of curves of light-distribution of different lamps. One of them was for the Keith high-pressure inverted gas lamp. In relation to it he said that his experience with these lamps was that the intensity of the beam was considerably steadier than that of the electric arc lamp as far as rapid changes were concerned. Next he showed a series of observations with an ordinary hand feed arc-lamp. From these results, and a number of others, he was convinced that he could obtain the candle-power of such a lamp to within 3 per cent from each test. Flame carbons (hand fed), were not capable of giving such constancy of results, as could be seen by the way in which the observations were peppered about on the diagram. There was still further difficulty with complete lamps which contained feeding mechanism.

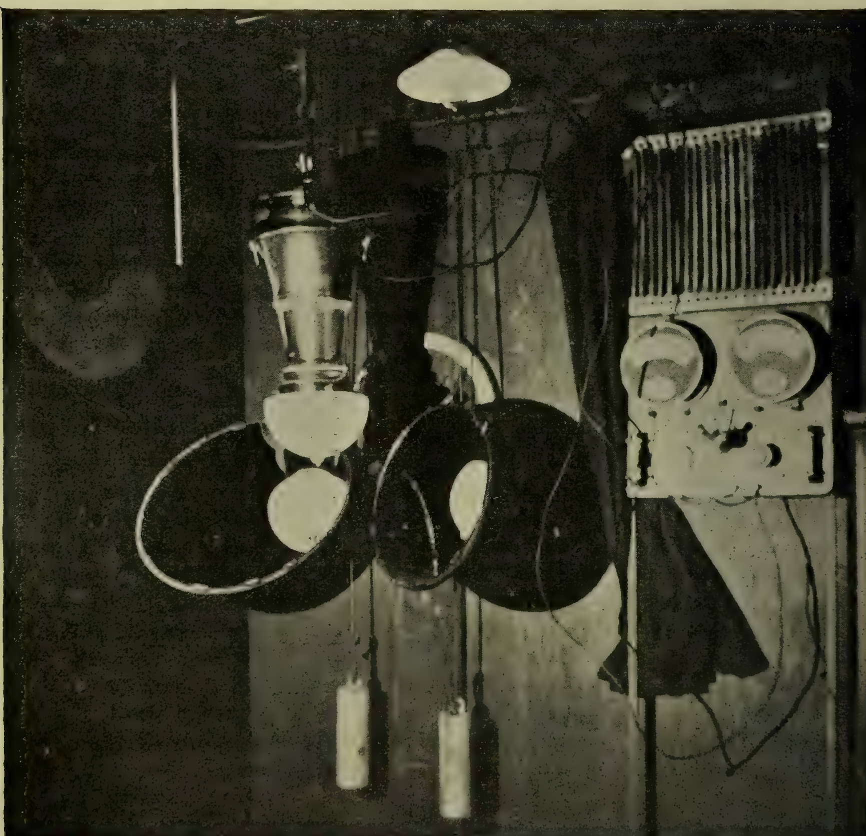

FIG. 1.—General View of Arc-lamp. Testing Arrangement.

Prof. Morris then showed a series of illustrations of the apparatus he had employed for this purpose at the East London College (see Figs. 1 to 5) made by Mr. E. T. Cook. It consisted essentially of a pair of plane oval-shaped mirrors

* See *The Illuminating Engineer*, Lond., Vol. I., 1908, pp. 627, 719, 871.

in symmetrical positions which could be rotated on the same axis, and which reflected their beams of light on to the photometer screen. The photometer thus received light from the two images but the direct rays of light from the arc were screened. By this means considerably greater accuracy could be obtained. Two advantages arose from this arrangement ; firstly, the arc lamp was fixed in position throughout the test, and its effective distance from the photometer remained unaltered, and secondly, by measuring the sum of two beams, taken from opposite sides of the lamp, one secured a more accurate and uniform result.

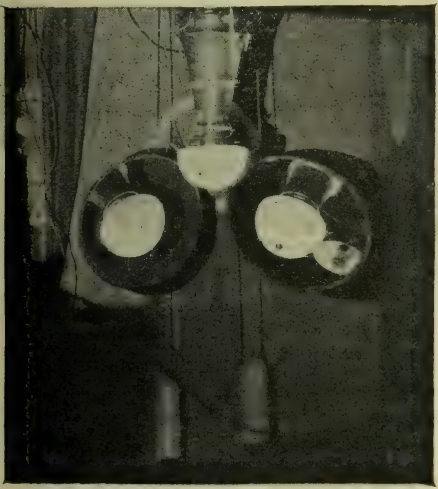

FIG. 2.—View from Photometer (with screen cutting off direct rays from arc removed).

FIG. 3.—View from Photometer, arc burning angle 40° above.

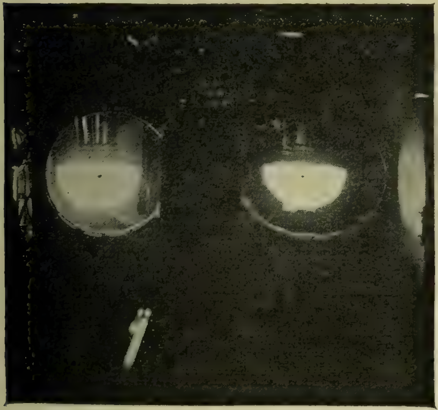

FIG. 4.—View from Photometer, arc burning, angle 0°.

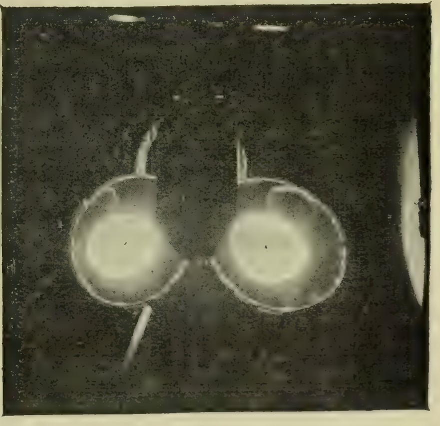

FIG. 5.—View from Photometer, arc burning, angle 40° below.

Mr. J. S. Dow then proceeded to read out abstracts of the communications from foreign members of the Society, which will be found *in extenso* on pages 238–247 in this number.

Dr. Clayton Sharp, he said, had laid stress on the value of the globe photometer. The Ulbricht globe was thought to be specially serviceable for measuring the absorption of globes, to which Prof. J. T. Morris had just alluded. In the

case of such arc-lamps as were inclined to give an unsteady light, it might be found of special value, since the total flux of light would probably be found to vary much less than the rays in any particular direction. In addition it was, of course, a great simplification to obtain the required result from a single reading instead of having to redetermine the polar curve of light-distribution for each globe or reflector tested.

Turning to Query No. 1, Mr. Dow said that he thought that the photometrical equipment at many technical institutions and colleges was out of date, and such instruments as the Ulbricht globe, which formed a regular feature in many institutions in Germany, seem to have received very little attention in technical colleges in this country. There was also a tendency to allow the courses of experiments on this subject to be of a more or less academic character, and to deal only with photometrical questions. Very little had yet been done in providing courses on general problems of illumination; these defects, however, would probably be remedied as the practical bearings of the subject came to be better realized.

Mr. Dow then referred to the question of the sensitiveness of photometers. As Dr. K. Stockhausen had pointed out, there did seem to be a surprising divergence between the results given by different authorities. It was necessary to decide on exactly what basis the sensitiveness of different instruments should be compared. It was not much use merely to take the mean of a number of readings, and to note how nearly such mean results could be reproduced; this would naturally yield much the same result, whatever instrument was used. A better method was to observe the mean deviation between individual readings. But probably the best method of procedure was as follows.

The photometer was gradually moved to such a position that it was *just* out of balance on the right and the reading noted. The corresponding limit on the other side of balance was next observed. Half the change in intensity of illumination corresponding to this range could then be taken as the smallest percentage change of illumination which the eye could detect with that instrument. Even to this method objections might be raised. For example, when oscillating the photometer and obtaining balance in the ordinary way, one probably recognized smaller changes than when a gradual movement was used. In addition the inertia of the carriage on which the photometer was mounted might have an influence on the result. But for *relative* results the method seemed a good one.

It was important to recognize that there was no real reason why we should not very greatly improve existing results. Physiologists, it was true, had in the past given certain figures in the neighbourhood of 1 per cent as the limit; but such determinations were merely the results of observation with apparatus which might now be bettered. Mr. Dow added that he himself could (with lights of the same colour) under the best conditions, detect a change of illumination of about 0·7 to 1 per cent. This meant that when working about the middle of a 2 metre bench the photometer would be kept within a range of about 2·8 to 4 millimetres on either side of zero. Of course the means of the series of readings could probably be repeated very much closer, and several authorities in Germany and the United States had suggested that, as far as the sensitiveness of the photometer was concerned, reproduction of readings within one-fifth and even one-tenth per cent might be possible. However, this was a matter which depended much on personal peculiarities, and any general conclusions must be based not only on a large number of readings, but also on the examination of a large number of observers.

Mr. Dow then referred to a table illustrating the contradictory conclusions reached by various authorities some of whom had used different methods of expressing the result.

It must also be recognized that the sensitiveness of the photometer depends on the illumination of the photometer screen. The speaker had carried out a

TABLE I.—SOME RESULTS BEARING ON THE RELATIVE SENSITIVENESS OF DIFFERENT TYPES OF PHOTOMETERS.

PERCENTAGE CHANGE IN ILLUMINATION PERCEIVED BY THE EYE.

(Wild, *Electrician*, November 8th, 1907.)

Type of Photometer.	Carbon lamps of same inefficiency.	Carbon and Osram.	Pentane and Inct. Gas.
	Per cent.	Per cent.	Per cent.
Ritchie Wedge	1·2	2·5	4·1
Joly Prism	1·25	2·4	4·15
Lummer Brodhun	0·35	1·75	4·0
Bunsen, single	0·6	1·8	4·35
„ double...	0·75	2·5	4·9
„ special single	0·2	1·6	3·9
„ special double	0·5	2·25	4·5
Trotter (badly made)	1·75	3·1	5·75
„ (carefully cut)	0·4	2·4	4·8
Simmance Abady Flicker	0·85	0·9	1·05
Wild Flicker	0·4	0·4	0·5

NETHERLANDS GAS COMMISSION (Stine, Phot. Measurements, p. 100).

The average setting of the following instruments departed from the mean by :—

Bunsen Photometer	± 0·08 per cent
„ „ with reflecting prisms	± 0·25 „
Foucoult Photometer	± 0·32 „
Lummer Brodhun Photometer	± 0·52 „

A. E. KENELLY (Nat. Elec. Light Assoc., Chicago, 1908).

Mean Probable Error, for a single balance :—

Grease Spot	1·52 per cent
Lummer Brodhun, Equality	0·78 „
„ Contrast	0·46 „

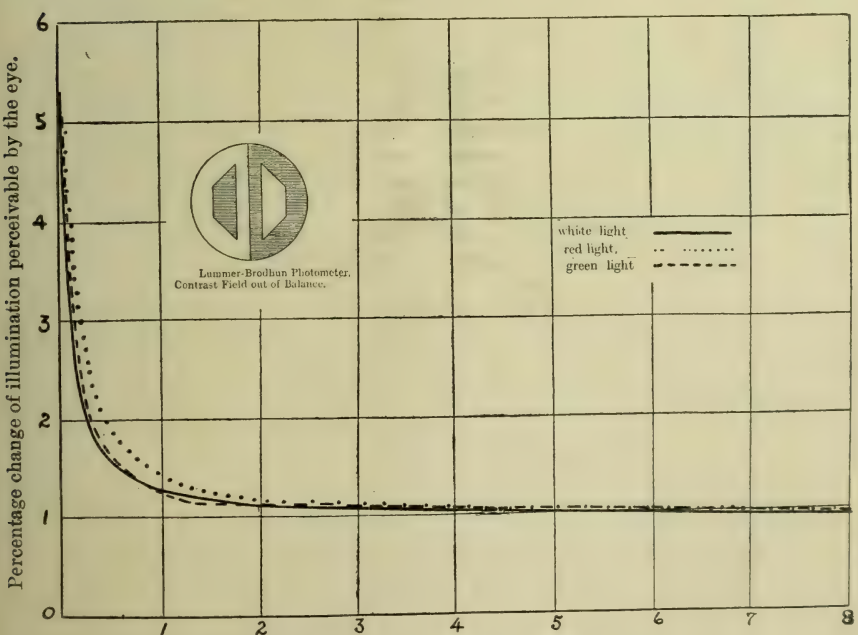

FIG. 1.—Showing Sensitiveness of Lummer-Brodhun Photometer with varying illumination of Photometer-screen. When the illumination is increased to 50 or 100 lux, the curve falls very gradually, to about 0·7 per cent.

number of researches with a contrast Lummer Brodhun photometer on this point (see Fig. 1). The curves shown represented the mean of hundreds of observations extending over several weeks, and carried out at the Davy Faraday Research Laboratory in 1907. When an illumination of about 10 lux was reached any further increase in illumination, even up to 100 or more lux, only led to a very small improvement in accuracy. It would also be noted that (for a given apparent *brightness*) practically the same results were obtained with red, green, and white light. This experiment probably represented the ordinary conditions of photometry. Koenig and Brodhun had made researches on this point of a very careful and exhaustive character.

Their results, rightly interpreted, were in good agreement with this curve. In their case, however, an artificial pupil orifice was used, and therefore the bend in the curve occurred at what they termed a higher order of illumination.

Mr. Dow then exhibited an experiment showing the differences in acuteness of vision by red and blue light. A box was divided into two portions illuminated respectively by a glow-lamp placed above the sheet of red glass, and a mercury vapour lamp screened by blue glass. Various qualities of detail were placed so as to be illuminated by the two lights, and it was then seen that the outlines on which the red light fell were much the sharper of the two, although the *brightness* was somewhat greater in the case of the blue.* This seemed to suggest that the detail-revealing power of an illuminant ought not to be confused with its "power of creating brightness"; a test of the former might be valuable, but it was certainly quite distinct from ordinary photometry.

In conclusion, Mr. Dow wished to express his indebtedness to the courtesy of Prof. T. Mather, F.R.S., for sanctioning the loan of apparatus from the Central Technical College.

Mr. L. Wild enquired whether a globe photometer in the form of a square or cubical box would answer the purpose. Or was it essential that the shape should be spherical? A cubical box would certainly be much simpler and easier to make.

The President, in closing the discussion, said that it was evident that the subject under discussion was very much too large to be covered in a single evening. The Society had before it an enormous—he would not say unexplored—field; it was, however, a field which had been left largely unworked by other societies. In bringing out so many points on which further knowledge was needed the Society was fully justifying its existence, if ever a society did. He thought it would be recognized, also, that the Society was acting wisely in devoting its first session to general discussions of this kind. No doubt in the next and future sessions, there would be many opportunities of dealing with subjects in detail and presenting papers on specific points. There would certainly be plenty of matter for discussion.

The President then proceeded to announce that the discussion would be resumed at the next meeting of the Society, when the more practical applications of the subject would be dealt with.*

* *Illuminating Engineer*, Lond., April, 1909.

* As announced on p. 226, the date of the next meeting is Thursday, April 14, 1910.

The Measurement of Light and Illumination.
Communications from Corresponding Members.
Dr. K. Stockhausen, Dresden.

Query 1.—My experiences are naturally confined to Germany, and in addition I must state that there are a number of technical colleges with the equipment of which I am unfamiliar. In general, however, it can be said that the study of illumination has not received the attention which its im-

portance warrants, at many of our technical institutions. In some cases adequate photometrical apparatus is provided for the measurement of electric sources of light, or for gas lighting, &c. But there is scarcely a single institution, possibly excluding the Hochschule in Charlottenburg, provided with apparatus enabling students to test *all* kinds of sources of light. It is still more exceptional to find experimental apparatus available for researches on general problems of illumination, apart from tests of a purely photometrical character. But this defect has come to be realized by authorities of recent years, and probably in a short time all the German technical institutions will be provided with excellent apparatus for carrying out photometrical researches.

In considering studies of this nature, it is particularly desirable to insist that researches should not be only of a purely scientific character, and that workers at the technical institutions and colleges should be in constant intercourse with those connected with the practical side of the subject. This is not only in the interest of the students themselves, but also in order to lead to the extension of interest and acquaintance with this question among the general public. A knowledge of the correct principles of illumination is of very general value. There can be no question that students of architecture, electrical and gas engineers, inspectors of factories and works managers, are at present often not afforded the facilities for the necessary knowledge on these subjects, though it would be of considerable value to them. In addition it seems to me unquestionable that there are a number of practical problems in connexion with illumination which call for careful scientific study and the solution of which would be of great benefit to the general public. Such questions should be referred to the large state-maintained scientific institutions, which possess exceptional apparatus and facilities for such study. Anything that the Illuminating Engineering Society can do in the way of calling attention to this need will be of inestimable benefit.

Query 2.—There are special points in connexion with tests of the sensitiveness of photometers, and the influence on such tests of personal peculiarities of the observer, which seem to me to require attention.

(*a*) In the case of most photometric instruments there is no proper arrangement provided to screen the eye from stray light entering it from the side. Now oculists have established the fact that light entering the eye in this way may be responsible for a considerable diminution in visual acuity—perhaps in some circumstances as much as 50 per cent. When the lights tested are rich in ultra-violet rays, such as may lead to fluorescence of the lens, these disturbances of vision tend to be accentuated. In such cases it is the light which enters the eye at a small "angle of glare," which is most influential. By this term "angle of glare" we understand the angle between the normal direction of vision and the line joining the offending source of light (for example, the sources of light compared or light reflected from the curtains or photometrical accessories) to the eye. But even when the angle of glare is as much as 90 degrees a powerful light visible out of the tail of the eye can cause a reduction of visual acuity of 25 per cent. Light received obliquely by the eye is not so disturbing when the surroundings are also brightly illuminated, but becomes correspondingly more trying as the background against which the offending source is seen becomes more sombre. Moreover, the actual field of view of the photometer usually possesses a relatively slight degree of brightness. Yet the process of judging balance, especially in the case of instruments of the "contrast type," makes considerable demands upon the acuteness of vision. Stray light entering the eye may therefore cause a distinct diminution in visual acuity, and therefore also reduce the sensitiveness of the photometer. In order to avoid this possibility of error the telescope should have attached to it some form of screen approximating to the observer's head in contour, and extending over the cheeks and forehead, so as to com-

pletely protect his eyes from the effect of stray light.

(*b*) In most cases too little account is taken of the effect of the adaptation of the eye. By this term we understand the reactions of the pupil aperture and the retina which enable the eye to accommodate itself to a certain range of illumination. This process does not take place immediately, but for purposes of fairly exact measurements we may regard the period of adaptation as being about 5 to 7 minutes. Still, it is also recognized that the greater part of the process of adaptation is completed in a very short interval of time after a change of illumination has taken place.

In any case the degree of the change depends upon the intensity of the change in illumination by which it is called forth. In the case of photometrical measurements, therefore, we must take precautions to secure that the observer is unable to see the source of lights tested; should he inadvertently do so, however, several minutes should be allowed to elapse until the eye is once more adapted to darkness. If the exposure is sufficiently severe to give rise to the formation of an after-image, a delay of at least a quarter of an hour is desirable before taking further readings.

(*c*) The human eye is only absolutely transparent in early youth. As I have explained previously,* in the course of life the eye lens becomes gradually yellow in tint, and in the case of old people this colouration may occasionally even become quite deep. However, the change does not always occur.

Now this gradual alteration in the eye lens has a considerable effect on visual acuity because it gives rise to the absorption of a portion of the blue and violet rays. On the other hand, it allows the yellow and green rays to pass unchecked, and the sensitiveness of the eye is a maximum for rays of this character. Hence it follows that for eyes of this kind the effect of a given flux of luminous energy is only weakened. Nevertheless, a yellow eye-lens is naturally influential when the measurement of lights of different colours is undertaken, especially when one of the two sources to be compared has a blueish tint. It is needless to say, too, that in the case of spectro-photometry it would have a disturbing effect.

Unless due precautions are taken, these three factors, stray light, the influence of adaptation, and the gradual yellow colouration of the eye-lens, may lead to uncertainty in tests of the sensitiveness of various instruments. In particular they may lead to misunderstandings in experiments designed to compare the sensitiveness of different individuals with one and the same photometer.

Indeed on examining the literature on the subject, one finds that far from consistent results are usually obtained when the sensitiveness of different types of photometers is compared; this may be partially ascribed to the fact that the three factors referred to have not been sufficiently borne in mind. Indeed, when we recall the numberless details which have to be paid attention to in order to secure exact results in photometry, we cannot but be impressed by the desirability of some method of measurement which should be independent of the peculiarities and complicated mechanism of the eye.

Query 4.—Considerable difference of opinion has existed for several years regarding the question whether the sources of light are best estimated in terms of mean spherical or mean hemispherical candle-power. I have already expressed the view that in such comparisons the mean spherical intensity is the only exact test.*

For such a system of comparison must be stated on a purely scientific basis. A knowledge of the mean hemispherical candle-power is, however, of great importance because it tells us most about the light from the lamp which is serviceable. Still, we must remember that the mean hemispherical candle-power can be enormously altered by the use of a larger

* *The Ill. Eng.*, Lond., March, 1910, p. 181.

* Stockhausen; Der eingeschlossene Lichtbogen bei Gleichstrom, Verlag von S. A. Barth, Leipzig, 1907, p. 191-197.

and better design of reflector, and, moreover, that the determination of the centre of radiation of such sources presents great difficulties.

The mean spherical intensity, on the other hand, can only be affected by an alteration either in the consumption of energy by a source, or in the light-producing mechanism. An alteration in the distribution of light has no influence on the result. On this ground valid scientific researches on the amount of light produced by different sources should be based on mean spherical candle-power.

In conclusion, I should like to draw attention to one other aspect of the matter which is of considerable practical importance in drawing conclusions from photometrical tests. We may express this aspect by asking the following three questions.

How much of the flux of light generated by a source—

(1) Reaches the eye-lens,
(2) Penetrates the eye-lens, and
(3) Produces a physiological effect upon the retina ?

These are questions on which we possess little positive knowledge. Measurements of daylight reveal the fact that at mid-day we have to deal with illumination of the value of thousands of lux ; on bright summer days values of over 80,000 lux have been obtained. A critical observer will naturally say that the retina never receives an image corresponding to this brilliancy. Yet how often do we find in the literature of the subject comparisons of the intensity of illumination by daylight and artificial light, in which no regard is paid to this possibility !

We have become accustomed to reasoning from the performances of photometers to conclusions regarding the effect of certain conditions on the eye. Photometers are really instruments specially intended to enable the eye to perceive small changes in illumination which it normally would not do. By their aid the eye can perceive very small changes in brightness, but cannot properly estimate very large ones. A very powerful intensity of illumination may act in an injurious manner on the eye, and therefore the eye has been provided with means of protection ; should the illumination change to an undesirable high value, the flux of light entering the eye is correspondingly reduced. Yet the actual value of the flux of light which can be permitted to enter the eye without risk of injury is not precisely known.

A measurement of illumination merely records the fact that a certain intensity is received on the surface of a photometer in a given horizontal or vertical plane. Yet the eye probably receives only a fraction of this illumination. One's projecting forehead, for example, cuts off a great deal of light coming from above. The nose, again, obstructs light coming from the right or left, and several oculists have drawn attention to the beneficial screening action of these portions of our anatomy.

Carrying our investigation further we see that the flux of light which actually reaches the eye-lens has next to pass through the corvea, and is subsequently vastly reduced by the pupil-aperture. How much of the incident light is absorbed in this process ? And what proportion of the light striking the retina produces a luminous sensation ? For what limits of illumination is the pupil-aperture active ? We do not know. We only know that the diameter of the pupil-aperture fluctuates between the limits of 2 to 7 millimetres. The area of the aperture through which the rays of light enters the eye can therefore vary between 3·14 and 38 square millimetres that is to say the light may be reduced to one-twelfth.

It is therefore obviously incorrect to regard measurements of intensity of illumination, obtained by photometrical means, as if they represented accurately the exact impression received by the retina. We must also be very careful in drawing conclusions from comparative measurements of daylight and the illumination produced by artificial illuminants, and specially in doing so on the basis of *brightness* of light only. In reality daylight has a variety of important functions to

perform quite apart from the incidental revealing of our surroundings.

In cases of artificial illumination we ought to aim at a value in lux so high that any increase in brightness adds only slightly to the acuteness of vision. There is a need for adequate investigations, applicable to modern conditions, on this subject, and it would be very desirable for exact researches to be made on this point in one of our great scientific institutions.

Dr. Louis Bell, Boston. So far at least as American colleges and technical schools are concerned, it is greatly to be regretted that substantial courses in illuminating engineering are practically unknown. It takes several years, according to the writer's experience, for new engineering ideas to penetrate the academic shell and stir the occupants to activity. In this matter of illuminating engineering there is a general lack of appreciation not only of the requirements for technical training, but of the nature and functions of the thing itself. There are still a good many otherwise well posted persons who cherish an obsession to the effect that illuminating engineering is a mere branch of electrical engineering to be taken as a side issue thereof, to occupy perhaps a casual place in instruction, but devoid of any independent importance.

One of our electrical papers called attention to the complete lack of instruction in illuminating engineering some months ago, and the comment drew forth three or four mild protests from institutions, mostly of small size, which claim to have introduced courses in illuminating engineering. These courses, and practically all others of which the writer has heard in this country, are merely makeshifts, having no real engineering significance at all, and being in reality mere laboratory and lecture courses in somewhat advanced photometry. Now photometry is an excellent thing in its way, but it is not illuminating engineering or any very considerable part thereof.

The recent discussion of the Illuminating Engineering Society on 'Glare' is the strongest possible evidence of the wide scope that must be covered by illuminating engineering and the necessity of instructional courses very different from anything which has yet been organized. A proper course of training in illuminating engineering should not only include the customary advanced photometry, but instruction in certain phases of electrical engineering and of gas engineering, advanced physics, physiological optics, and æsthetics from the architectural standpoint. For it is the business of the illuminating engineer not only to measure light, but to know at first hand the properties of the materials of illumination, whether electric energy or petroleum. He must also be trained in physical optics to get some grasp of the phenomena of illumination apart from its mere measurement; he must understand what illumination should do and should not do with relation to the organs of vision, and he must have a firm grasp on the fundamentals of sound design as regards the æsthetic value of illumination.

It seems, therefore, clear that an attempt to make instruction in illuminating engineering a side issue in a course of practical electricity is very likely to end in failure. With whatever department such a course is nominally allied, which is a mere matter of academic bookkeeping, it requires for its successful working the cooperation of at least four or five departments. Students in electrical engineering, gas engineering, and in architecture might properly be required to take some thorough general courses in illuminating engineering, but the subject must be recognized as one with ramifications reaching several distinct fields of investigation, and as one which cannot be summarily put aside with a few lectures and laboratory exercises on the use of illumination photometers, and a few mathematical demonstrations of the illumination received from a theoretical light source.

One of the chief difficulties at the present moment is that there are no text-books on illuminating engineering in English worthy of serious consideration. What few books on the subject exist are mostly either too popular for text books or too exclusively photometrical. In the writer's judgment the

best possible course of illuminating engineering could be given by the co-operation in lectures and other exercises of instructors from the departments of electrical engineering, chemical technology, physics, physiology, and architecture. Such a course need not cover a very great range of work in any one of the departments, but all the instruction given should be thoroughly co-ordinated so that the student may acquire a clear and broad view of the relations of these various branches of science to the art of artificial illumination. And after all it is more an art than a science, which is added reason for not attempting to relegate it to a subordinate position in any one particular technical department.

Dr. C. H. Sharp, Electrical Testing Laboratories, New York :—Very great progress has been made in the last few years in devising methods and producing apparatus for the convenient and precise measurement of mean spherical candle-power, mean hemispherical candle-power, luminous flux, and illumination values.

The first practical integrating photometer was, I believe, that of Matthews, which he and others have turned to splendid account in measurements along these lines. Integrating photometers of similar type have also been produced in Europe. More recently the demonstration by Ulbricht of the advantages of the integrating sphere as a means of measuring the luminous output of a lamp, has brought this remarkably simple and effective apparatus into great prominence.

With the production of apparatus capable of giving these characteristic mean measurements with precision and without undue labour, the importance of measurement of this character has come to be much more widely recognized. The result is that we have to-day extensive data on the various luminous sources expressed in terms which are capable of exact definition. When an arc lamp is designated as giving so and so many mean spherical candle-power, the luminous output of the lamp is at once known, whereas if it is given in candle-power of any other description, the luminous output remains an unknown quantity.

The utility of the concept of luminous flux, both in the computation of illumination values and in the designation of the output of illuminants, is also coming to be recognized by practising illuminating engineers. This has resulted in a very great simplification of the operation of computing mean illuminations, and is also undoubtedly leading us to the point where the luminous output of lamps and the efficiency of lamps shall be designated in terms of the luminous flux and of the luminous flux per watt or per cubic foot per hour. Furthermore, a more adequate appreciation of the importance of illumination data as describing the final results achieved in the use of illuminants, together with the production of improved apparatus for the measurement of illumination, has resulted in a more extensive employment of the various units in terms of which illumination is measured.

The introduction into engineering practice of concepts and terms which have hitherto been regarded as more or less academic, brings us face to face with the necessity for the establishment of an acceptable system of nomenclature and for the definition of units for the measurement of these quantities, which are as yet rather new in the field of illuminating engineering. Such a system must be able to withstand the scrutiny of the scientific man, and must at the same time be satisfactory to the practising engineer.

The Illuminating Engineering Society has at present a sub-committee which is at work on this problem, and which made a preliminary report at the Convention of the Society held in New York last October. It seems to me that the British Society will undoubtedly find it desirable in the near future to take some similar action. It would be unfortunate if the system adopted in the two countries should be at variance with each other at any point, and therefore I would beg to make the suggestion that the matter of the appointment of a Committee to take up the consideration of this question be brought to the attention

of the British Society with a view to eventual co-operation of the two Committees with each other. Personally, I feel quite sure that the American Committee would welcome such action on the part of the British Society most warmly, and that the result of such co-operation could not fail to be very beneficial.

Preston S. Millar, New York :—The selection of the measurement of light and illumination as the topic of discussion for the last meeting of the British Illuminating Engineering Society is significant, and illustrates a growing appreciation of the importance of the scientific study of illuminating problems. In this field the measurement of light holds a place of much importance.

During the four years of activity of the Illuminating Engineering Society in the United States of America, there have been presented before the Society thirty-four papers dealing with lighting installations. It is interesting to note that in nineteen of these papers there have been included photometric studies of lamps or illumination. In fact, 30 per cent of all the papers included in the first four volumes of the *Transactions* deal with questions of photometry or include reports of photometric tests. This might seem to imply undue or disproportionate attention given to photometry, but it is perhaps natural that those interested in the measurement of light should be the first to take active part in the work of an illuminating engineering society. However that may be, there is every reason to believe that photometry will continue to find a large place in these *Transactions*.

In the United States there is a growing appreciation of the value of photometry in lighting practice. Every consulting illuminating engineer provides himself with a photometric outfit, or has occasional tests made by some testing organization. To a greater or lesser extent, photometric study has become a feature of the work of most consulting illuminating engineers, and so we find reported, tests to determine illuminating efficiencies, or the ratio between the flux of light delivered on a working plane whose illumination is the chief object of the installation, and the total flux of light produced in the installation ; studies of depreciation in the efficiency of a lighting installation due to collection of dust, and other effects of lack of proper maintenance ; studies of the reflecting power of walls and ceilings ; and studies of illumination produced in streets.

The extent to which photometry enters into lighting practice in the United States is more or less well understood by those who have followed the technical press for the last few years. Gas lamp manufacturers have compiled elaborate data on light distribution and efficiency of gas lamps variously equipped, and are placing these at the disposal of gas companies. The gas companies continue to sell gas on a basis of candle-power, although the agitation in favour of a calorific value is beginning to have effect.

It has long been the most approved practice among central stations furnishing electrical service to draw strict specifications as to the rating of incandescent electric lamps, and to so arrange the purchase of these lamps that reasonable compliance with such specifications will be obligatory.

It is now the almost invariable practice for manufacturers of reflectors and globes to furnish light distribution curves with their reflectors in order to contribute towards the intelligent use of their appliances.

Although the rating of lamps is still based upon unidirectional or zonular values, a clearer understanding prevails concerning the necessity for basing comparisons of lamps upon total flux of light, and this is the practice very generally adopted at this time, although to a large extent we still entertain the notion of mean intensity rather than light flux.

In general in this country, precision photometry is carried out upon bars of the Reichsanstalt type, while in industrial work, convenient forms of semi-enclosed, carefully screened photometers are available, built generally by those who use them. Light distribution apparatus is used to a limited extent only, due to the fact that on

practically all forms of illuminants, light distribution data, vouched for by independent authorities, have been published.

Integrating photometers are not used largely, the Matthews integrating photometer having been installed in but few laboratories, while the "Globe" photometer, which is rather new in this country, is only beginning to find the use to which its merits would seem to recommend it.

Satisfactory portable photometers are available and are meeting with increasing use.

I have chosen to present a few generalities rather than to enter specifically into a discussion of the very interesting list of queries which have been submitted. Practically all meritorious forms of photometric appliances have been described in the technical press, and I therefore have nothing to contribute on this subject which is not already available.*

Mr. G. H. Stickney (SCHENECTADY, N.Y.).

No. 1.—The principal technical colleges of this country have ample facilities for physical photometric measurement as far as the science has developed. Much more, however, is yet desired as regards the facilities for measurements covering the commercial application. There is, of course, a demand for devices which will reduce labour and give reliable results more automatically.

No. 3.—In our laboratory we use several different photometric combinations to meet the requirements of different conditions. For small symmetrical sources the single mirror photometer is used. For unsymmetrical sources a double mirror photometer is used. For light sources of large area we have designed a special arrangement, eliminating all mirrors. This photometer is so constructed that we can mount a ceiling 10 ft. square above the lamp so as to measure the ceiling reflection. All our photometers are arranged so that they can be worked at a constant radius (usually 10 ft.).

Two of our photometers can be adjusted for constant illumination on the screen or constant length of the bar. For careful readings on steady sources we use the Lummer-Brodhun screen. For sources of variable intensities we prefer to take a large number of quick readings with the Bunsen screen.

We consider it very important to have our measurements made by experienced observers. Under these conditions we obtain remarkably good results with the bunsen screen on lights of different colours.

In the determination of mean spherical candle-power from photometric curves we have followed two methods :—

I. By applying the cosine constant to 10° readings.

II. By integrating a curve plotted on cosine paper.

The former method is quicker, and not liable to any large error. The latter method, when carefully applied, seems to be slightly more accurate, particularly with irregular curves.

No. 4. The writer believes that the mean spherical candle-power is the one single figure which comes nearest to expressing the light value of an illuminant. But while it measures the value of the source as a light producer, it is not always a true measure of the source as a producer of useful illumination. In places where practically all upward light is wasted, the mean candle-power in the lower hemisphere is a more useful unit of comparison. This, however, is often wrongly applied as a general comparison where lamps may be used beneath white ceilings. The practice which we follow in sending out photometric data is to give a polar curve, showing the distribution along with the mean spherical and mean hemispherical candle-power figures. This permits the results to be interpreted according to the requirements of particular problems.

No. 5. I know of no general method which suits all cases. We usually employ the Bunsen or the Lummer-Brodhun contrast screen. We have made some

* See 'Illumination Photometers and their Use,' by P. S. Millar, paper presented at the First Convention of the Illuminating Engineering Society, U.S.A., Boston, 1907.

tests with the flicker photometer, but as its results differ from the other screens we have avoided complications by adhering to our former practice until the correctness of the flicker photometer has been more thoroughly established.

No. 6. In connexion with our illuminating engineering work we have made a large number of illumination measurements. The practice which we have followed seems to the writer to be the most practicable one for commercial work. We have used two types of instruments: one for high intensity readings—usually under indoor conditions; and one for low intensity readings as in ordinary street lighting. As a high intensity illumination photometer there has been developed, under the direction of Mr. Ryan, the luxmeter, which is suitable for measuring intensities from one-half a foot candle upward through a reasonable range. This instrument measures the intensity of illumination falling on a surface—either horizontal, vertical, or otherwise, according to the position of the instrument. It corrects well within the requirements of commercial accuracy for oblique angles of incidences.

The instrument is self-contained, and is so arranged that the observer need not cast a shadow upon the screen. We have made a very large number of measurements, some of which have been compared with those of other instruments, and the results have been exceedingly satisfactory. The luxmeter has simply been made up for our own use, and has never been placed on the market. It was especially got out for store lighting measurements, but we have used it also for high intensity street lighting measurements.

For ordinary street lighting we have found it more practicable to measure the intensity of the beam at various distances from the light source rather than attempt to measure the low intensities falling on the surface of the street. In some cases we have introduced the cosine factor and calculated the intensity on the surface of the street, but ordinarily we use only the intensity of the beam in making our comparisons. This method, for example, was followed in presenting the data before the National Electric Light Association.

M. F. Lauriol (Paris). I hope to deal with *Query* 2 in greater detail on a future occasion. As regards *Query* 3 I myself utilize the well-known mirror arrangement in order to determine the polar curve of light distribution of a source. According to this method an inclined mirror is rotated on a revolving arm in such a manner that the ray coming from the source at different angles is constantly directed along the photometrical bench for measurement (this ray, however, strikes and leaves *the mirror* at the same angle).

In subsequently working out the mean spherical or mean hemispherical candle-power I utilize the well-known Rousseau diagram. In determining the mean spherical candle-power, when it is not necessary to know the polar curve of light distribution, I make use of the Ulbricht globe. According to the dimensions of the illuminant to be tested, I employ two sizes of this instrument, which are respectively 80 centimetres and 2 metres in diameter. I understand that the globe can also be used to measure mean hemispherical candle-power, but I have not actually tested it for this purpose, and consider its use in this connexion somewhat doubtful.

Query 4. The real value of an illuminant may be expressed either in terms of the mean spherical or the mean hemispherical candle-power, and sometimes it is necessary to know both. In a street, for example, assuming that comparatively little light is reflected from the houses, a knowledge of the lower hemispherical candle-power is most important. In a room with white ceiling and white walls, on the other hand, probably the mean spherical candle-power best represents the total amount of light used for general purposes of illumination. In general, I think it is desirable to state *both* the mean spherical and mean hemispherical candle-power of illuminants, and to consider both in framing any comparison. Only in special circumstances should one's reasoning be

based on either of these quantities separately.

Query 5. This is an exceedingly complicated question. I have published several technical papers dealing with the matter in connexion with the proceedings of the International Photometric Commission at Zurich in 1907, and elsewhere. Briefly, I consider that in the case of two illuminants which differ in colour it is impossible to state that the illuminating power of the one is *invariably* any multiple of that of the other. If certain conditions occur this may be true; under other circumstances it may not. In order to approach a fairly accurate result I consider the use of a photometer of the Ritchie type preferable. It is also necessary to make a series of different measurements with varying illumination of the photometer screen, if possible from 0·1 to a 1,000 lux, or at least from 0·5 to 50 lux.

To-day we have to deal with many illuminants which differ considerably in colour such as arc-lamps, carbon, and metallic filament lamps, incandescent lamps, incandescent mantles, oil lamps, &c. We have sometimes even to deal with radically different colours, as in the case of the red and green lamps used for railway signalling.

Leaving out of account special lamps of the latter kind, however, and confining ourselves to commercial illuminants, there seem to me to be three questions on which definite information is needed. How greatly do results depend upon,

(1) The intensity of illumination of the photometer screen.

(2) The different types of photometers employed.

(3) The peculiarities of different observers?

And even if, theoretically, we are able to say that this or that illuminant is double as powerful as some other, how far can this result be applied to describe the conditions in practice? What percentage of error is involved in such an assumption? Unfortunately I have not sufficient leisure to work out these question alone, and I think it is one with which a number of laboratories ought to deal.

Queries 6 *and* 7. This is a matter with which I have not had much personal experience. It is a matter for consideration in what plane a measurement of illumination should be made. It has been proposed to measure it at the level of the ground; also in an horizontal plane at a given distance above it; also in a vertical plane. But it does not seem thoroughly established which of these methods most completely represents practical conditions.

We have also received from Dr. A. C. Humphreys, President of the Stevens Institute, U.S.A., a letter in which he expresses his great interest in this subject, and states that he hopes to contribute some remarks shortly.

Dr. Humphreys adds that many years ago he had already made efforts to draw the attention of gas and electrical engineers to the importance of studying the measurement of light and illumination.

Glare; its Causes and Effects.

Further Communications from Correspondents.

Prof. George J. Burch, University College, Reading (*communicated*):—

Several distinct phenomena are usually classed together under the head of glare. As, for example, :—

1. After meeting a motor car with an acetylene head-lamp on a country road at night, it is impossible for some seconds to see the oil lamps of any bicycles that may be following it. This is due to the intense negative after effect of the brilliant light impressed upon the yellow spot—the very part of the retina we use in steering by a light. It is a source of danger to cyclists

2. The glare of a snowfield, or of the sun upon the sands, or the gold rims of a pair of spectacles, is due, as Dr. Parsons has pointed out, to an excess of illumination on the peripheral regions of the retina interfering with the functions of the yellow spot. In some

countries hunters blacken the skin below the eyes with gunpowder to reduce the light reflected from the face.

3. A greatly intensified sensation of glare may be experienced in travelling past trees or palings in a railway carriage when the sun is low. The passage of the shadows in rapid succession across the pages of one's book produces an almost painful effect. The late Dr. Shelford Bidwell told the writer that he had found the effects of such intermittent illumination so deleterious as to necessitate his relinquishing his investigation of the subject.

4. A fourth variety of glare is due to irregular refraction or cloudiness in the eye itself, and concerns, therefore the ophthalmic surgeon rather than the engineer.

I agree with Mr. J. S. Dow's suggestion that Dr. Stockhausen's proposal to take the duration of after images as a criterion of glare is attended with difficulties; I fear it would lead to no reliable result. From a large number of measurements extending over nearly thirty years I conclude that the period varies greatly in different individuals, and moreover, varies in the same individual according to the state of his health. Cases have been recorded of after-images persisting for ten or twelve hours when the light used has been merely that of the blue sky.

I have seen them for nearly four hours myself, though as a rule definite images fade away in considerably less than an hour. The rate of maximum flicker too is subject to a considerable variation.

Undoubtedly there is what one might call a normal rate of decay for after-images. So also is there a normal rate of pulse, and one might conceivably by some automatic arrangement for recording the beats of it, make a new kind of clock. But it would hardly do to catch trains by!

Dr. C. H. Williams (Boston, U.S.A.). In the number of *The Illuminating Engineer* (of London) for February, 1910, I find a very interesting discussion on the subject of 'Glare,' and on p. 98 in query No. 6 you ask "What instruments are available for measuring in a simple manner the intrinsic brilliancy of any luminous object?"

My "Simplex" photometer,* is designed for this purpose, and the photographic films of increasing density, on which it depends, being non-selective enable it to be used for the determination of the relative intrinsic brightness of lights, coloured as well as white. In this respect it is better than the glass wedges often used and which generally affect some colours more than others.

This photometer measures the relative intrinsic brilliancy of lights, but does not measure the amount of light. For instance, if we examine the filaments of a 16 and of a 32 c.-p. incandescent electric lamp at a distance of 20 ft., each filament burning supposedly with the same intensity, we shall find with this photometer that their intrinsic brightness is the same; but as the filament of the 32 c.-p. lamp is longer than the other it gives a greater amount of light. On the other hand, if we examine the filaments of a number of lamps which have been burning different lengths of time, such as those round the cornice of a room, we can, without removing them from their positions, measure their relative intensity, and see how much one differs from another, or from a normal standard.

Again, with signal lights, we can thus measure the relative intensity of distant signal lights, either white or coloured, and compare them with a standard light. So also the relative value of such lights in penetrating an atmosphere more or less loaded with smoke or fog can be measured by testing them under such conditions.

I have recently made a few tests of some of the light-houses near Boston Harbour, and it has been interesting to see how much the varying conditions of weather affected the relative intensity of these lights. The engineer of the first and second U.S. Lighthouse Districts has just purchased one of these photometers, and I hope that he will obtain some interesting results.

* *The Ill. Eng.*, Lond., Vol. I., June, 1908, p. 506.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909).

New Members of the Society.

At the meeting of the Illuminating Engineering Society held at the house of the Royal Society of Arts on March 15th, 1910, the names of the applicants for membership read out at the previous meeting on February 15th were formally approved and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on March 15th :—

VICE-PRESIDENTS.

Mordey, W. M.	Past President of the Institution of Electrical Engineers, 82, Victoria Street, LONDON, S.W.
Violle, M.	The Originator of the Violle Standard of Light, 89, Boulevard St. Michel, PARIS.

ORDINARY MEMBERS.

Barham, G. R.	Works Manager, of the British Luxfer Prism Syndicate, 16, Hill Street, Finsbury, LONDON.
Jones, H. W.	Chief Electrical Engineer of the Waterloo and City Railway, 8, Altenburg Gardens, Clapham Common, LONDON, S.W.
Knight, J. D.	Borough Electrical Engineer of Ealing, the Town Hall, EALING.
Levy, Dr. A.	Opthalmic Surgeon, 67, Wimpole Street, LONDON, W.
Slaughter, T. E.	Electrical Engineer, London Electrical Supply Corporation, 25A, Cockspur Street, LONDON, W.
Venner, R. F.	Electrical Engineer, 6, Old Queen Street, Westminster, LONDON, S.W.

CORRESPONDING MEMBERS.

Schanz, Dr. F.	Opthalmic Surgeon, 10, Münchenerplatz, DRESDEN.

OFFICIAL NOTICE.

DATE OF ANNUAL GENERAL MEETING.

It has now been decided that the **Annual General Meeting** of the Society will take place on **Monday, May 23rd,** at 8 p.m., at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), when it is hoped that all members will make a special effort to be present.

As announced elsewhere (p. 226) the **next meeting** of the Society is to take place at the House of the Royal Society of Arts on **Thursday, April 14th**, when the discussion on "**The Measurement of Light and Illumination**" will be resumed, and **The President, Professor S. P. Thompson, D.Sc., F.R.S.**, will take the chair.

* A list of these names will be found in *The Illuminating Engineer*, March, 1910, page 191.

Street Lighting with Tungsten Incandescent Lamps.

THE value of high candle-power Tungsten lamps for street lighting, and especially for the less important thoroughfares, has attracted considerable attention in this country. In the United States the use of these lamps has already been extending rapidly, and one interesting method which has found favour in many quarters, is the arrangement of a series of lamps in arches spanning the street. An example is furnished by the adjoining illustration.

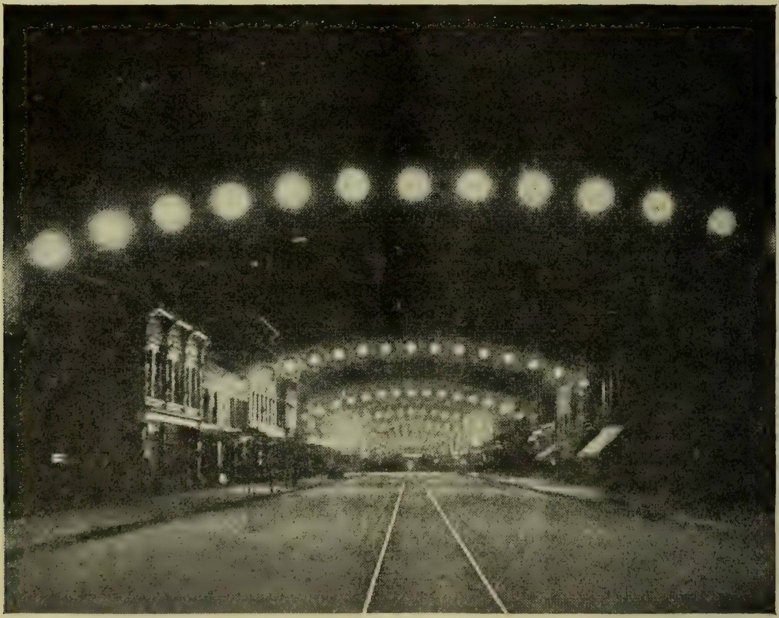

FIG. 1.—Showing festoons of metallic filament lamps slung in arches crossing the roadway.

The arrangement is regarded as being specially convenient for festive occasions as such lamps can be so easily installed at short notice. In addition, the use of a number of small units in preference to one large one, is said to promote good distribution of light, and also lends itself to decorative effect. In order to achieve this last result it is of course essential that due attention should be paid to the proper screening of the lamps.

This is yet another illustration of the competition of high candle-power tungsten lamps with arc lamps. Remané,* and others have contended that, under certain conditions, the incandescent lamps are the cheaper, and now that filaments yielding as much as 1,000 candle-power are becoming stock articles, it will be interesting to watch their development for outdoor lighting.

* See *The Illuminating Engineer*, vol. i. p. 861, 1908.

The Physiological Effects of Radiation.

By Dr. C. P. Steinmetz.

(Address before The Illuminating Engineering Society in the United States, Third Annual Convention, 1909. Abbreviated.)

(*Continued from p.* 96.)

I mentioned that glass is perfectly opaque to radiation of very short wavelength. A very high frequency or a medium frequency ultra-violet radiation cannot penetrate glass, and glass, therefore, affords, as far as I know, a practically perfect protection against harmful ultra-violet light. Glass is not quite opaque to the longest ultra-violet waves, but probably for about one-quarter of an octave beyond the visible ultra-violet light, the light penetrates glass to a certain extent.

You see we have in the ultra-violet light a very wide range of radiation in which the danger increases from practically nothing, at the upper range of wave length, to an extreme destructiveness at the highest frequency. Where, therefore, you have to deal with arc and spark discharges, as in the case of wireless telegraph apparatus, &c., it is necessary, for protection, to enclose the source of light in glass. In that case, however, you must realize it is not sufficient merely to interpose a glass plate, because you still get reflected light, and reflected ultra-violet light is also harmful; you must enclose the source of light entirely by glass, otherwise, probably in a reduced degree, but still quite marked, you get the harmful effect of ultra-violet light. Wearing glasses affords considerable protection, but not absolute protection, because enough stray light comes in so that you will notice it, as I found when I looked at a low temperature quartz mercury lamp for a few minutes. The other gentleman, who looked at it without glasses, is not quite well yet, and that was eight years ago.

So far we have discussed the specific physiological effect of radiation on the eye, more particularly the harmful effect. There are, however, effects not only on the eye as an organ, which is made to notice radiation, but on the living organisms in general. Radiation exerts a powerful effect on living protoplasm, on animal and vegetable life. The most important effect of radiation is undoubtedly that on plant life. The energy of plant life is derived from the energy of radiation of sunlight; and the radiations which do the chemical work on the plant are the long waves of the red and orange and yellow. The chemical action of radiation is undoubtedly some kind of a resonance effect. We find that the relatively heavy silver atom—atomic weight 108—responds to the shortest visible rays and the invisible ultra-violet rays; that is, the maximum actinic power for silver compounds probably is at the end of the violet or beginning of the ultra-violet. The much smaller oxygen atom—weight 16—does not respond to these radiations, but responds to the extreme end of the ultra-violet, about one or two octaves higher: a higher frequency, as would be expected, is the resonance frequency. On the other side, when we come to the much heavier complex carbon radicles of the organic compounds of plant life, you see we must expect them to respond or resonate with lower frequencies than even the silver atom, and so we find that plant life is responsive to the extreme end of the long waves of the spectrum, to the red and orange and yellow.

Ultra-violet light again is harmful. As we may expect, the frequency is so short that heavy groups of carbon atoms cannot respond to it, but the individual atoms may respond and may cause dissociation, that is, death, while it is the rearrangement of the atomic groups which we call life.

The animal kingdom cannot utilize the energy of radiation. Nevertheless, radiation also exerts a physiological effect on the animal or human body when impinging on it. The effect is the same as that of any powerful agent : it is stimulating when of moderate intensity, and destructive when of high intensity. The stimulating effect may be used therapeutically to a certain extent, and is being used as a convenient method, especially in cases where the metabolism is sluggish, to increase rapidity of circulation, similar in effect to the static field, for instance. Thus radiation power, or light, has a decided stimulating effect on man, when of moderate intensity, while excessive intensity causes harm ; excessive exposure to sunlight we know causes sunburn, which, when severe, leads to the destruction of the surface tissue of the body which has been exposed.

The effect of radiation on lower organisms, micro-organisms, is also very interesting. Many micro-organisms, germs, live in the light. They can stand a considerable amount of light, though possibly direct sunlight may kill them. There are other germs which are used to live in the dark, and are killed by light. Thus micro-organisms which have been developed in light, require light, and are killed by darkness, and micro-organisms which have been developed in the darkness are killed by light. Thus amongst the putrefactive bacilli—germs of decay—there are those which require light and air and those which live in darkness, and would be destroyed by daylight. Especially is the latter the case with the disease germs which live in the interior of the body, in darkness. They, therefore, are used to the dark, and light is fatal to them. As a result disease germs are more or less rapidly killed by light, and especially direct sunlight is one of the most powerful germicides and disinfectants. The tuberculosis bacillus is especially sensitive to light, and is almost instantly killed by direct sunlight. The greatest prophylactic method, therefore, is to flood our homes with light—instead of that we do exactly the opposite. We very carefully exclude sunlight, to keep the carpets from fading. Direct sunlight is the most powerful germ destroyer.

As light destroys pathogenic germs, disease germs, it is important to consider its application as a therapeutic agent in combating these germs in the human body. In surface infections, as tuberculosis of the skin (*scrofulosis*, *lupus*) light has become a very powerful therapeutic agent and is the most efficient method of cure. When you come to deeper seated infections, you see the difficulties become very much greater, because the tissue of the human body is nearly opaque to radiations, especially ultra - violet radiation, which are the most powerful destroyers of germ life, and we cannot get a sufficient intensity of radiation far enough down into the body, without destroying the surface tissue. We naturally think of X-rays as radiations which penetrate through the body, and for deep-seated affections they are used, and have a beneficial effect. We must realize, however, that they are already so far in frequency from the visible light, the solar radiation, that the acclimatization which the human body has acquired against solar radiation does not exist to the same extent against these very much higher frequency X-rays, that is, the difference of sensitivity of disease germs and of the cells of the human body to X-rays is much less than for long ultra-violet rays, and therefore the range wherein we can kill the germs without harming the patient is very much narrower, and the conditions very much more risky than when using the long ultra-violet waves.

The Use of Metallic Oxides in Arc Lamp Electrodes.

By Dr. B. Monasch (Augsburg).

Introductory.

Very early in the history of electric lighting, attempts were made to utilize various metallic oxides in the arc light. As a rule these researches took the form of placing the metallic oxide in question between the carbon electrodes, thus bringing it to incandescence.

The refractory nature of such oxides, it was supposed, would enable the lamps to burn for a longer time without the electrodes being renewed, and it was also believed that their presumable good qualities as radiators of light and energy would lead to a high luminous efficiency. The oxides were, as a rule, either arranged on the electrodes themselves,[1] or immediately adjacent to them.[2]

Usually this device did not lead to any practical result, for the metallic oxides or salts melted under the heat of the arc, spread out over its surface, and on cooling, formed a glassy slag, which subsequently gave rise to much spitting and flickering. In addition, this product of combustion tended gradually to cover the active surface of the carbon electrodes, with the result that the luminous efficiency deteriorated in the course of time.

[1] A. Fleming, D.R.P. 114568, 1899.
Union Elektricitäts Gesellschaft, D.R.P. 149718, 1902.

[2] Jablochkoff, Brit. 494, 1877, D.R.P. 663, 1877. D.R.P. 8785, 1879.
Rapieff, Brit. 4432, 1877, Brit. 211, 1879.
Newton, Brit. 4960, 1878.
Harding, Brit. 4047, 1878.
Scott, Brit. 4671. 1878.
Heinrichs, D.R.P. 10054, 1879.
Pilleux, D.R.P. 12531, 1880.
Bureau, Brit. 1704, 1880.
Tihon and Rezard, D.R.P. 28981, 1882.
Gould, D.R.P. 31066, 1884.
Brin, Brit. 11381, 1885.
Fröhlich, D.R.P. 112339, 1898.
Bonhivers, D.R.P. 112313, 1899.
Koch, D.R.P. 123789, 1900.
Haunach, D.R.P. 131910, 1902.
Cotis, Brit. 217060, 1902.
Nush, Brit. 26157, 1904.

It must also be remembered that, at the beginning of the study of this subject there were not any adequate means of judging the illuminating values of different sources of light, and, largely in consequence of this, the actual values of metallic oxides and other refractory bodies as a means of adding to the light of the arc were often much overestimated. The fact established by the researches of Auer v. Welsbach, that the oxides of the rarer earth metals could, under certain conditions, be heated to incandescence in a gaseous flame, and the knowledge resulting from the work of Nernst, that certain mixtures of metallic oxides would conduct at a high temperature, and were then good radiators of light, also led to an array of patents on this subject. In these cases the applicants frequently paid little attention to the actual relations affecting the production of light by means of an arc, and were satisfied that an enormous improvement in light production would follow simply from the use of metallic oxides. In this article we shall see later that the arcs of most of the metallic oxides are of comparatively small value as producers of light.

It has also been proposed to utilize the heat of the arc to render oxides of this kind conducting, and so supplement the light from the arc itself by that of an incandescent filament, placed in series.[3] This arrangement also presents certain difficulties in actual operation and has led to small practical result. For example, it involves an undesirable complication of the mechanism of the lamp.

[3] Körting and Mathiesen, D.R.P. 111619, 1898, D.R.P. 111173, 1899.
L. T. Magee, D.R.P 152004, 1901.
Vogel, D.R.P. 140686, 1902.
Brundelmayer, Öster. Pat Anm. A. 3904, 1904.

Rasch[4] has also proposed to strike an arc between rods composed of metallic oxides of the same kind as those utilized in the Nernst lamp. But as yet no serviceable arc lamp of this kind has found its way into practice. The use of such rods is attended with many difficulties. For example: they are non-conductors at ordinary temperatures, and must, therefore, be preheated before they can be used as light producers. In addition, if the electrodes are brought into contact in the heated condition, they are apt to stick together and to cause a short circuit; the current then increases enormously and the electrodes may melt along their entire length. Under ordinary conditions, when the current is switched off, and the electrodes are in contact again, the same thing may occur; and, moreover, Nernst filaments are distinctly brittle and become much distorted after they have been used in this way for a short time.

An arc lamp between two Nernst rods is, as will be shown later, a very inefficient means of producing light. Still, the light given from such a light would be considerably greater than that due to the arc pure and simple, since the electrodes themselves when so used are incandescent almost along their entire length. In fact, photometrical experiments show that the main source of light is not the arc, but the electrodes. When this is realized, it becomes evident that the arc lamp has become practically a glow lamp, and such incandescent filaments are best adapted to the usual form of Nernst lamp.

A more hopeful method of using metallic oxides to form arcs was that of Stark[5], who proposed to utilize the principle that negative electrions are radiated mainly from the cathode, and that, therefore, the behaviour of an arc is mainly controlled by the latter, and does not require a high temperature at the anode. The researches of Granquist,[6] Schulze,[7] and Blondel,[8] have added materially to our knowledge of the processes taking place in the electric arc. The nature of arcs built up between various metals and metallic oxides has also been dealt with in the work of Steinmetz,[9] Weedon,[10] and Whitney.[11]

Observations on a large number of conditions of different materials showed that the quality of light and the electrical conditions were altered quite differently according as a certain

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4 Ewald Rasch, E.T.Z., 22, pp. 155 and 373, 1901. Verfahren zur Erzeugung von elektrischen Licht.

Ewald Rasch, D.R.P. 117214, March 3rd, 1899, announced Jan. 12th, 1901. Verfahren zur Erzeugung von Elektrischen Bogenlicht.

Ewald Rasch, D.R.P. 137788, March 28th, 1899, announced Jan. 9th, 1903. Verfahren zum Anlassen von Elektrolyt-oder Bogenlampen.

W. Nernst, E.T.Z., 22, p. 256, 1901, Bemerkungen zur Notiz des Herrn Rasch.

E. Rasch, Drud. Ann. der Physik, 11, p. 202–206, 1903, Gasentladungen an elektrolytischen Glühkörpern.

B. v. Czudnochowski. Berichte der Deutsch. Physik. Gesellschaft, 5, p. 157–176, 1903, Flammen- oder Effektbogenlicht.

E. Rasch, Berichte der Deutschen Physik. Gesellschaft, 5, p. 276-286, 1903, Flammen-oder Effektbogenlicht.

J. Stark, Physikalische Zeitschrift, 5, p. 81-83, 1904. Zündung des Lichtbogens an Metalloxyden.

B. v. Czudnochowski, Physikalische Zeitschrift, 5, p. 99-103. Über den elektrischen Lichtbogen zwischen Leitern zweiter Klasse.

E. Rasch Physikalische Zeitschrift, 5, pp. 375–379, 1904, Gasentladungen und Lichtbogen mit glühenden Leitern zweiter Klasse als Strombasis.

Zur Patentlage:—J. L. Roberts, U.S.P. 460595, 1891.

Electroden, G.m.b.H., D.R.H. 143302, 1900

„ „ „ 143303, „

„ „ „ 144968, „

Sander. D.R.P. 137576, 1899; Brit. 3751, 1900, D.R.P. 148257, 1901.

Campagnie Générale d' Electricité, Paris, Brit. 17 1507, 1905.

5 J. Stark, Drud. Ann. der Physik, 12, pp 673-713, Zur Kenntniss des Lichtbogens.

6 G. Grandquist, Über die Bedeutung des Wärmeleitungsvermögens des Elektroden bei dem elektrischen Lichtbogen, Upsala, 1903, Akad., Buchdrückerei, 56 Seiten.

7 G. Schulze, Drud. Ann. der. Physik, 12 pp., 828–841, 1903, Spannungsverlust im elektrischen Lichtbogen.

8 A. Blondel, Transactions of the International Electrical Congress, St. Louis, 1904.

Vol. II., pp. 731–767, Properties and Industrial applications of the electric arc, produced by means of electrodes of carbon mixed with mineral substances.

9 C. P. Steinmetz, *The Electrician*, London, 51, pp. 171–172, 1903. The mercury arc.

Electorial World, 43, p. 974, 1904. The Magnetic Arc Lamp.

10 W. S. Weedon. *Electorial Review*, (N Y) 44, p. 622-626, 1904. A contribution to the study of the electric arc.

11 W. R. Whitney. Transactions of the American Electrochemical Society, p. 291–299, 1905. Arcs.

material was used for the anode or cathode respectively. These researches have led to the construction of the magnetite arc lamp.

The Magnetite arc lamp, manufactured by the General Electric Co., utilises an arc between an upper anode of copper and a lower cathode of a powdered mixture of special composition. This composition consists of:—Magnetite (Fe_3O_4) 65 per cent, Titanium oxide (TiO_2) 25 per cent, and the double oxide of chromium and iron ($FeO.\ Cr_2O_3$) 10 per cent. This mixture is pressed into an iron tube. The dimensions of the anode are so selected that it does not become appreciably heated, and therefore does not furnish any appreciable amount of copper to the arc; the anode, therefore, should not waste away to any great extent. One difficulty encountered in the use of magnetite electrodes is the deposition of a red-brownish product of combustion (Fe_2O_3) which appears in long flakes on the anode, and tends also to form a deposit on the mechanism and accessories of the lamp. Special measures are, therefore, necessary to protect them from this dust and also to guard against the deposition of a layer of brownish dust inside the globe of the lamp.

The efficiency of the magnetite lamp can be controlled within considerable limits, and was so selected as to enable the lamp to compete as regards cost of energy with other commercial illuminants. The life of an electrode, 16 millimetres in diameter, 200 millimetres in length, and consuming 4 amperes with 75 volts across the arc, is about 150 hours. The mean hemispherical candle-power of the lamp under these conditions is about 400H.K. without the globe. Magnetite arc lamps have found wide application in the United States.[12]

[12] Hillman, *Electrical World*, 44, p. 335, 1904. The Magnetite Arc.
Fleming, *Electrical World*, 47, p. 714, 1906.
Barstow, *Elektrotechnik und Maschinenbau*, Vienna, 24, p. 656–657, 1906, Bericht.
Birge, *Electrical World*, 48, Seite, 531–553, 1906.

Experiments.

In order to study the value of various metallic oxides for the generation of light, and to utilise them in a form which enables an arc to be built up without any special subsidiary devices, the various materials were reduced to a fine powder and pressed into a cylindrical tube 10 millimetres diameter and 0·2 millimetres thick. These tubes formed the cathode of the arc investigated. Unless anything is said to the contrary, it will be assumed in this article that the anode was the upper and the cathode the lower of the two electrodes. Throughout this experiment the anode consisted of a slab of copper 5 millimetres thick and 50 millimetres in diameter. In order to render the cathodes serviceable for further experiments, the following process was carried out. The arc was struck between an iron tube filled with metallic oxide and some other metallic electrode, the edge of the iron tube being between 2 to 3 millimetres higher than the core of oxide powder. Under these conditions the arc was easily struck, the edge of iron melted away and the arc then settled on to the core and melted the oxide; after a short time the electrode consisted of a more or less liquid cup of molten oxide, containing a certain amount of iron. After cooling the electrodes so treated almost invariably enabled an arc to be started and maintained from a 220 volt circuit and in the cold state. Calcium fluoride, however, gave rise to a glassy slaggy surface which did not enable an arc to be struck. In the case of certain pure metallic oxides, such as those of calcium, magnesium, aluminium, thorium, &c., the surface was non-conducting.

Since the researches of Dr. Steinmitz had shown that a magnetite arc was a comparatively good light producer and as, in addition, powdered magnetite was known to be a good electric conductor in the cold state, it was considered advisable in the researches now to be described to utilise this material as the basis of the mixture employed and to add to it various metallic oxides in suitable portions.

In each case an arc taking 80 volts and 4 amperes was maintained from the supply P.D. of 220 volts, the horizontal candle-power in Hefner candles being measured in each case by means of the Weber Photometer.

Since the light of the arc studied was invariably derived from the column of luminous vapour and not from the crater of the electrode the horizontal candle-power was always the approximate maximum. For the same reason the nature of a polar curve of light distribution was approximately the same in the case of the different electrodes. A fairly satisfactory comparison of the light in each case could thus be made in terms of horizontal candle-power. It must, however, be pointed out that these figures are not

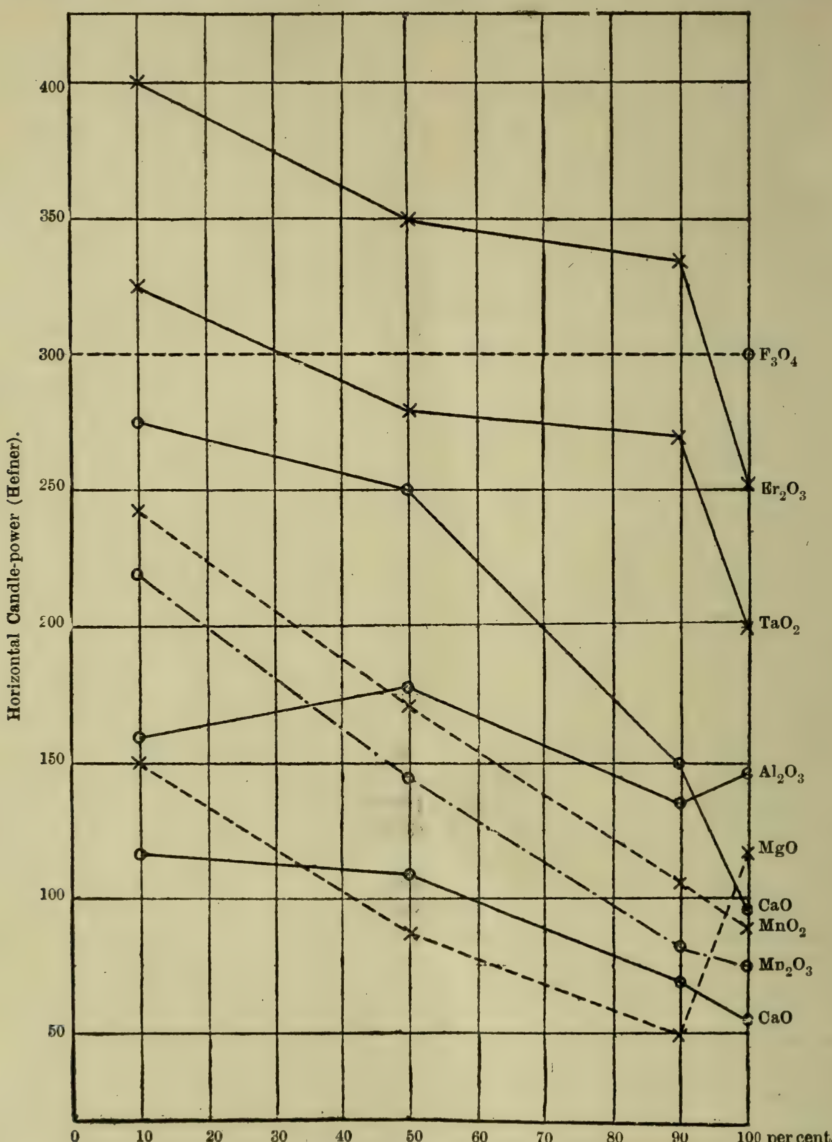


FIG. 1.

directly comparable with those obtained for an ordinary open pure carbon arc since the curve of light distribution is in this case essentially different, most of the light coming from the incandescent crater. The majority of the light is then thrown downwards, and therefore a comparison with the metallic arc, in terms of horizontal candle-power, would be too unfavourable to the carbon arc. In comparing the two types of arcs due consideration must, therefore, be given to the polar curve of light distribution and a comparison should preferably be made in terms of mean spherical or mean hemispherical candle-power.

The following materials were employed :—

- Aluminium oxide ($Al_2 O_3$), white.
- Calcium oxide ($Ca O$), white.
- Cerium oxide ($Ce O_2$), yellowish-white.
- Ferro-chromium oxide ($FeO Cr_2 O_3$) grey-brown.
- Chromium oxide ($Cr_2 O_3$), green.
- Cobalt oxide ($Co O$), black.
- Iron oxide ($Fe_2 O_3$), red-brown.
- Erbium oxide ($Er_2 O_3$), bright red.
- Cupric oxide ($Cu O$), black.
- Cuprous oxide ($Cu_2 O$), red.
- Magnesia ($Mg O$), white.
- Magnetite ($Fe_3 O_4$), black.
- Manganic Oxide ($Mn_2 O_3$), black.
- Manganese dioxide ($Mn O_2$), black.
- Nickel oxide ($Ni O$), greyish green.
- Tantalum dioxide ($Ta O_2$), white.
- Titanium oxide ($Ti O_2$), yellow-brown.
- Thorium dioxide ($Th O_2$), white.
- Uranium oxide ($U O_3$), red.
- Yttrium oxide ($Y_2 O_3$), yellowish white.
- Vanadium oxide ($V_2 O_3$), brown.
- Tungsten dioxide ($W O_2$), brownish black.
- Tungsten trioxide ($W O_3$), yellow.
- Zinc oxide ($Zn O$), white.
- Zirconium oxide ($Zr O_2$), white.

In Figs. 1, 2, and 3, the abscissæ represent the percentage of special material which has been added to the magnetite cathode. The ordinates denote horizontal candle-power and represent the mean of a large number of readings. It is naturally impossible to regard these figures as extremely accurate, since in many cases the arc light was somewhat unsteady. This was particularly characteristic of the group of oxides for which the cathode was in a completely molten condition while the arc was produced, for example calcium oxide. In such cases periodic movements and alterations in the cathodic surface give rise to considerable fluctuations in the light. In the case of the less volatile metallic oxides, for example zirconium oxide, it is only the portion of the surface on which the arc is actually burning, that is molten. The arc thus burns from a pool surrounded by solid material. Hence, in shifting its position, it is apt to form new pools in different parts of the surface, which therefore comes to assume a very rugged character. It will, therefore, be readily understood that under these conditions the length of the arc could not be measured with any great accuracy even when the corresponding current and p.d. were rigidly specified.

Another source of error is introduced by the difference of colour of the light yielded by various arcs, as compared with the standard ; in this case benzine lamps and Osram incandescent lamps were used. Arcs which yield mainly blue and green light can, of course, hardly be said to have a direct bearing on practical conditions ; in reality it is only possible to compare the brightness of such sources by suitable spectrophotometric measurements of light of different wavelengths.

Under the electrical conditions specified magnetite gave a very quiet arc, yielded light of a white colour tinged with blue, and developed a horizontal candle-power of about 300 H.K. In Figs. 1 to 3 the results of experiments on other metallic oxides are given. One can see from Figures 1 and 2 that the addition of most of the oxides studied has the effect of reducing the light from the magnetite, and it is proportionately diminished the greater the addition of foreign material. It is only the oxides of certain rare metals, such as $Ce O_2$, $Y_2 O_3$, $V_2 O_5$, $Ti O_2$, VO_3, WO_2, WO_3, as shown in Fig. 3, which exhibit a higher luminous effect than magnetite.

The candle-power yielded by most pure metallic oxides without the addition of magnetite (for examples ;

Ca O, MgO, Al_2O_3, Co O, Ni O, Mn_2O_3, in Fig. 1), is very small. This fact seems the more remarkable because most of these materials, especially MgO, CaO, ZrO_2, Al_2O_3, have been referred to very hopefully by many applicants for patents from 1880 upwards. The behaviour of the metallic oxides as producers of light when the material luminesces in the arc seems, similar results, but in this case the limit of improvement is reached nearer 50 per cent. It seems, therefore, that we have here, in this improvement of the luminous efficiency of the arc by the addition of various metallic oxides, a phenomenon somewhat similar to that which is to be noted in the effect of mixtures of oxides in the incandescent mantle. An incandescent mantle com-

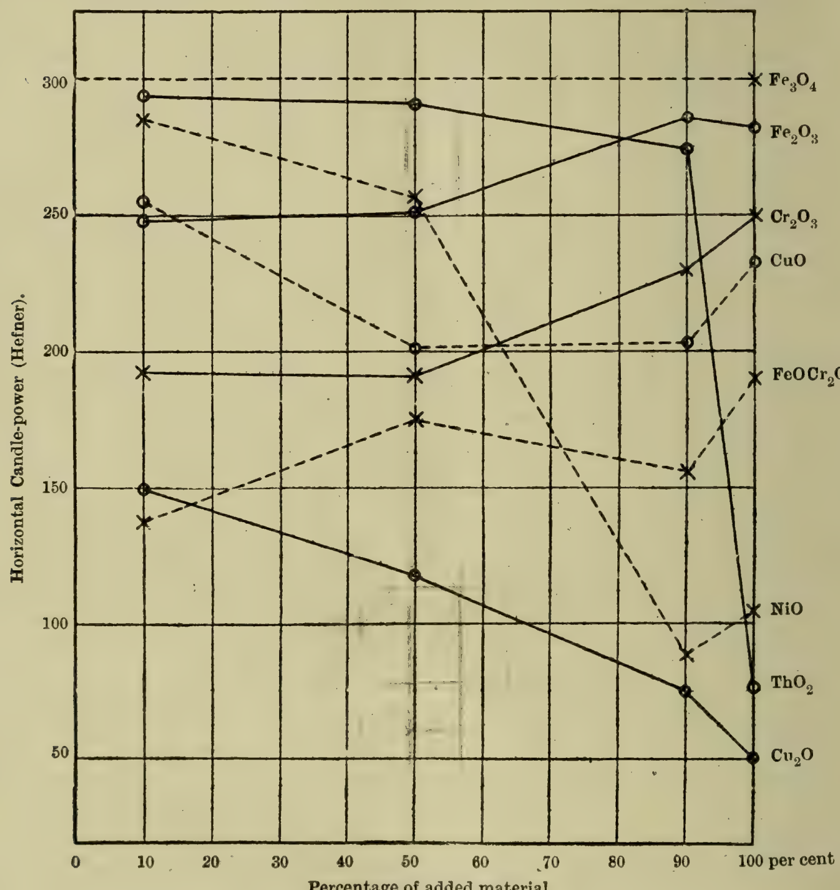


FIG. 2.

however, to be distinctly different from that exhibited when they are brought to incandescence in the solid state.

The course of the curve for zirconium oxide is shown in Fig. 3. Additions up to 60 per cent. improve the candle-power of the magnetite arc, but higher percentages cause diminution. The zinc oxide gives rise to posed of thorium oxide alone is known to give practically no light at all. The high lumious efficiency of the mantle is due to the addition of small traces of cerium oxide. Thus the addition of one per cent. of cerium to 99 per cent. of thorium oxide gives rise to the maximum luminous effect, but each addition of cerium oxide beyond this point causes the light to diminish more and

more; eventually, when 10 per cent. of cerium oxide has been added, there is again practically no light produced.

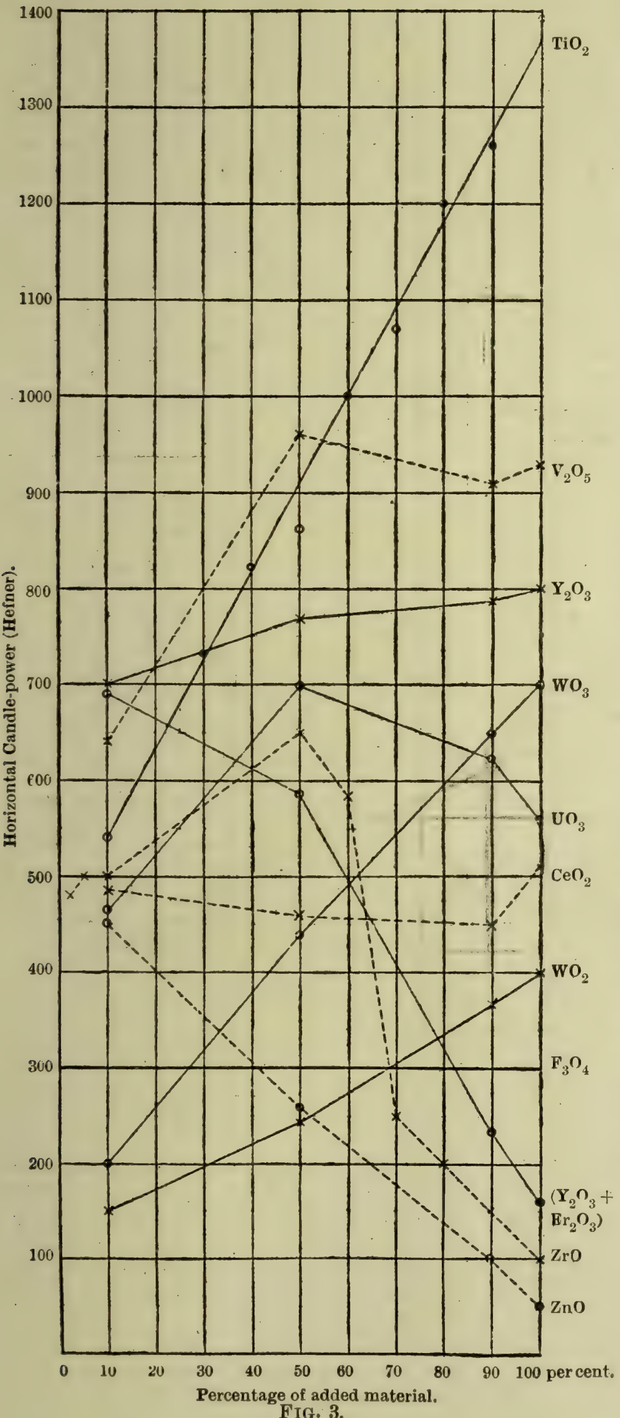


FIG. 3.

Titanium oxide (TiO_2) is an excellent light producer. It will be noted in Fig. 3 that each addition of this material to the magnetite causes an improvement in the light until the maximum effect is reached by the pure titanium oxide alone. It will be noted that while the addition of magnetite to metallic oxides of the type referred to in Figs. 1 and 2, constitutes an improvement, the addition of magnetite to titanium oxide leads to deterioration in the light. In the same way all those metallic oxides referred to in Fig. 3 (*e.g.*, V_2O_5, V_2O_3, CeO_2, VO_3, WO_3) are to some extent spoilt as producers of light by the addition of magnetite. The apparent trifling improvement in the light characteristic of 50 per cent. Fe_3O_4, and 50 per cent. V_2O_5, and also 50 per cent Fe_3O_4 and 50 per cent VO_3, may be caused by incomplete mixture of the two materials at the cathode.

At the conclusion of this research of metallic oxides several other refractory substances, the addition of which to the arc has often been suggested, were studied. These were examined in exactly the same way as those materials treated in Fig. 1 to 3, being enclosed in an iron tube and utilised with the copper anode. They gave rise to the following luminous intensities:—

Carborundum, 100 per cent, 75 H.K.

Fire clay .. 100 per cent, 48 H.K.

Kaolin .. 100 per cent, 50 H.K.

By the addition of magnetite to these materials the luminous intensity was improved; yet it was always less than that of the pure magnetite. Calcium fluoride, which has found a wide application in the cores of flame carbons of the production of yellow light, gave in a pure condition a higher luminous intensity than titanium oxide, namely, 1940 H.K. at 80 volts and 4 amperes. The addition of magnetite causes the luminous intensity to fall rapidly, 90 per cent of magnetite and 10 per cent of calcium fluoride giving only 450 H.K.

The pure metals are relatively bad producers of light. In Table I will be found the results of experiments on several such metals.

TABLE I.

Various Metallic Arcs (Current 4 amps., P.D. across arc 80 volts).

Cathode.	Anode.	Horizontal Candle-power.	Colour of Light.
Iron Rod, 10 mm. diam.	Iron Rod, 10 mm. diam.	107 H.K.	Bluish.
"	Copper Rod, 10 mm. diam.	141 "	"
Iron Tube, 10 mm. diam., filled with fine iron powder.	"	99 "	"
Copper Rod, 10 mm. diam.	"	25 "	Green.
Aluminium Rod, 6 mm. diam.	"	28 "	Bluish-Green.
Iron Tube, 10 mm. diam., filled with magnesium powder.	"	169 "	Bluish.
Silicon block.	"	80 "	Yellowish.
Iron Tube, 10 mm. diam., filled with titanium powder.	"	549 "	Yellowish-White.
Iron Tube, 10 mm. diam., filled with tungsten powder.	"	196 "	Bluish.

(*To be continued.*)

The Association of Engineers in Charge.

THE Annual Dinner of the Association of Engineers-in-Charge will take place in the King's Hall, Holborn Restaurant, London, W.C., at 6 P.M., on Saturday, April 9th. Tickets for the dinner, over which the President, Henry Adams, Esq., M.Inst.C.E., M.I.Inst., M.E., &c., will preside with the Right Hon. the Lord Mayor, and the Sheriffs of the Corporation of London as the guests of the evening, can be obtained by addressing the Hon. Secretary at St. Bride's Institute, E.C., to whom an early application by members and friends should be made.

The Distribution of Energy in the Spectra of Commercial Illuminants.

By W. W. Coblentz.

(The following paper has been kindly presented by Dr. W. Coblentz, of the Bureau of Standards, Washington, U.S.A., as a communication for discussion at the hands of The Illuminating Engineering Society. The paper is an exceptionally exhaustive one, and will be continued in subsequent numbers of this journal. It is hoped that a special opportunity for discussion will be provided when this paper has been concluded. Meantime we shall be glad to receive any communicated remarks on the subject, which we will subsequently submit to Dr. Coblentz for final comment.—Ed.)

(*Continued from p. 155.*)

Emission Spectra of Flames.

The finding of sharp emission bands in solids was entirely unexpected, for only in gases was it supposed that such sharp bands could exist. Under the present heading we shall consider the emission spectra which result from the combustion of gases with the accompaniment of variable quantities of incandescent solid carbon particles. Such energy curves are given in Fig. 9, curves a = acetylene, b = Hefner, c = Bunsen flame, respectively. The acetylene flame gives an intense continuous spectrum due to the presence of the incandescent carbon particles, with a maximum emission at 1·2 μ. Upon this continuous spectrum is superposed an intense emission band of CO^2 with a maximum at 4·4 μ. The indentations of the curve at 1 to 3 μ are due to atmospheric absorption bands of water and of carbon dioxide. The Hefner flame is weak in visible radiation due to the absence of carbon particles, and hence the energy curve at 1 to 2 μ is very weak. The emis-

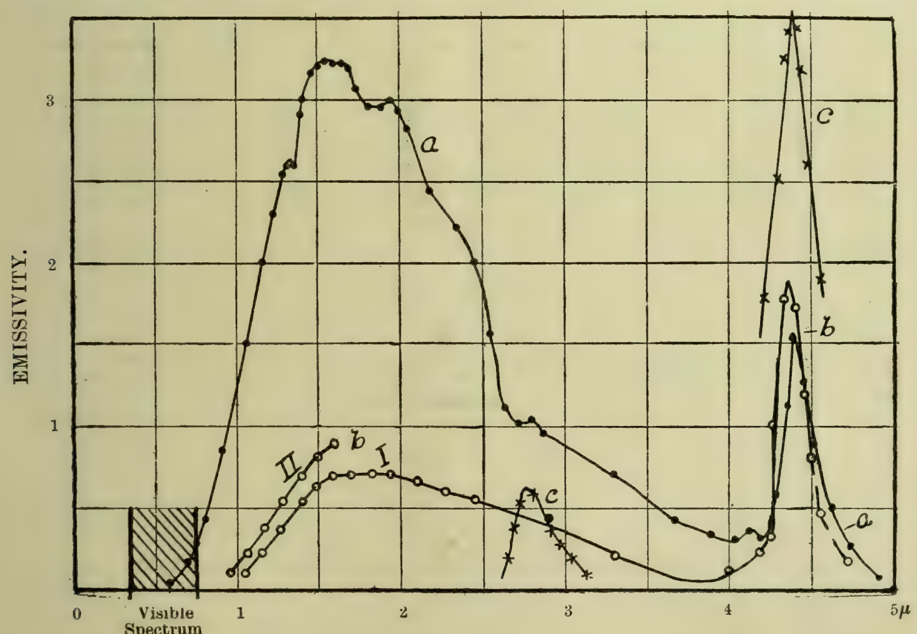


Fig. 9.—Radiation from Acetylene Flame (a) from Hefner (b) and Bunsen (c).

sion band of the hot carbon dioxide occurs at 4·36 μ and is as intense as that of the acetylene.

In the Bunsen gas flame all the carbon is consumed and no luminous radiation is emitted. The products of combustion are water vapour and carbon dioxide. Practically all the radiation from this flame is emitted by the carbon dioxide bands, *c*, *c* at 2·75 μ and 4·4 μ respectively.

Arc Emission Spectra.

The partition of energy in arc spectra occurs in sharp lines often superposed upon a weak background. The strong continuous spectrum, if present, comes from the electrodes. This is well illustrated in the carbon arc. The pure carbon (graphite) vapour emits intense bands in the violet and ultra-violet, the hot electrode giving a continuous spectrum. Impurities of metals, whether accidental or whether introduced purposely, as in the latest form of "flaming arcs," impart colour and raise the luminous efficiency of arc lights. The arc spectra of the metals are characterized by a group of strong emission lines just beyond the visible spectrum, as shown in the spectrum of potassium, Fig. 10, followed by a weak emission at 2 to 3 μ. Using a large dispersion, recent experimenters have been able to resolve the weak continuous emission into distinct lines. The band at 4·55 μ is found in common in all spectra of metals in the carbon arc, and is due to carbon dioxide. The importance of the results of these observations lies in the information given as to the probable temperature of the metal vapours. Since most of the intense lines are shifted up close to the visible spectrum, following the analogy with the observations on the oxides and other radiators in which the emission lines in the short wave-lengths appear with rise in temperature, it is inferred that a temperature of about 3,000° C. obtains in the metals in carbon arcs.

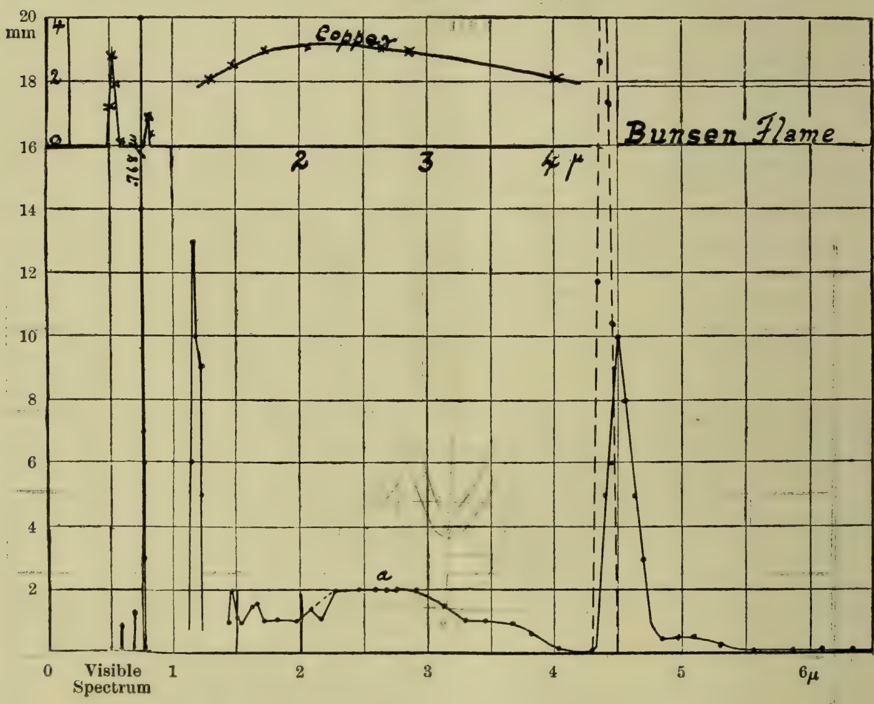


Fig. 10.—Potassium (in carbon arc) Copper Arc (upper curve).

Copper[1] produces but little oxide

[1] Coblentz: Investigation of Infra-Red Spectra. Carnegie Publication No. 35, p. 303.

when an arc is formed between metal electrodes. Its low luminous efficiency is, therefore, due to some other cause than an excessive emission of infra-red rays in proportion to the visible light emitted. The spectral energy curve of the vapours from an arc using copper electrodes is shown in Fig. 10, from which it will be seen that the band in the visible spectrum is as strong as the infra-red.

The transparency of the human eye for ultra-violet and infra-red rays has been the subject of numerous investigations.[2] For the ultra-violet the cornea and crystalline lens are more opaque than the aqueous and the vitreous humours.

The combination, forming the complete eye, transmits to the retina wave-lengths as short as 0·3 μ. The most complete investigation of the transparency of the eye to infra-red radiation was made by Aschkinass.[3] He found the eye transparent to 1.4 μ in the infra-red, where occurs the first large absorption band of water. Helmholtz found that the eye detects radiation to wave-length 0·8 μ. One must, therefore, conclude that the retina is not sensitive to 1·4 μ in the infra-red. The human eye is almost 2 cm. thick, and hence if composed of water only would not permit infra-red waves longer than 1·5 μ to reach the retina. When light is suddenly flashed into the eye, for example, as would occur on a short circuit arc, the eye-lid is instantly and involuntarily closed. If the short circuit arc occurs on heavy conductors they would not be sufficiently heated (before the eye is warned) to send out heat waves that can penetrate to the retina. If the conductors are actually melted (melting point of copper is 1,063° C.), the maximum energy lies in the region of 2·1 μ, so that but an extremely small amount is of wave-lengths shorter than 1·4 μ, and hence can impinge upon the retina and shock the optic nerve. Furthermore, the chances are that the eye would be closed involuntarily, as a result of the flash of light before the conductors could become sufficiently heated, even assuming that the radiation from the latter can penetrate to the retina. Since the vapour has practically no infra-red radiation, it seems

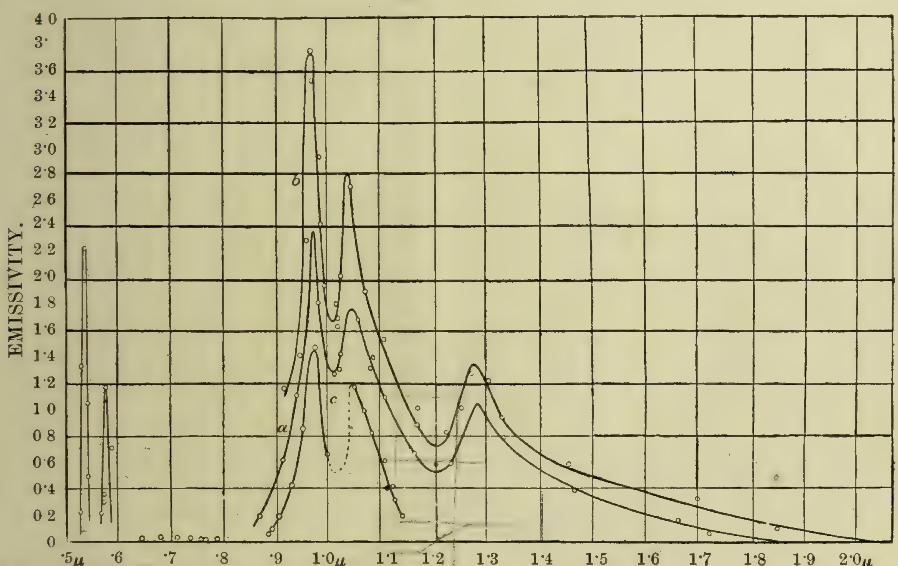


Fig. 11.—Mercury Arc.

[2] See Kayser's Handbuch der Spectroscopic, vols. 1 and 3.

[3] Aschkinass, *Ann. der Physik*, (3) 55, p, 401, 1895.

as though we must look elsewhere for an explanation of the fatigue and pain caused by short circuit arcs. For a physiological effect of infra-red radiation from short circuit arcs on the eye[4] is highly improbable.

In commercial work probably the majority of accidental arcs occur on short circuits of copper or brass conductors, often in dimly lighted places. Now, the dominant colour of the copper arc is yellowish green, and hence is the most violent stimulus to the eye (since the latter is the most sensitive to the yellowish greenish part of the spectrum) and it seems more probable that the sudden blow of this light is the cause of injury to the optic nerve. While photographing the light of the fire-fly, which required one to stay in a dark room for several hours, it was found that the pupil became so dilated that the sudden flash of light from this insect was painful to the eye, the unpleasant effects lasting for a day or more.

The mercury arc is similar to that of other metals. It has several small emission bands at 1μ, so that the ratio of its luminous radiation to its total radiation is quite high. The infra-red emission spectrum, Fig. 11, was first observed by Coblentz and Geer[5] at a time when the existence of infra-red emission lines of metals was still doubted. They used an old type of Arons lamp open to a mercury pump. Subsequent observers, notably Moll[6] and Paschen[7] have not been able to find the line recorded at $1{\cdot}05\,\mu$ in Fig. 11, which is, in common with a nitrogen line found in a vacuum tube, to be considered hereafter. All agree in locating weak lines out to about $2\,\mu$. The most intense lines lie in the region of $1\,\mu$, as in the metals in the carbon arc.

[4] According to the report of the Illuminating Engineering Society's proceedings given in the *Electrical World*, Oct. 7, 1909, p. 820, Steinmetz, in examining into the physiological effects of radiation, concludes that in the case of a short circuit arc the blow to the eye can be said to be due almost exclusively to the infra red radiation.

[5] Coblentz and Geer, *Phys. Zeit.*, 4, p. 257, 1903.

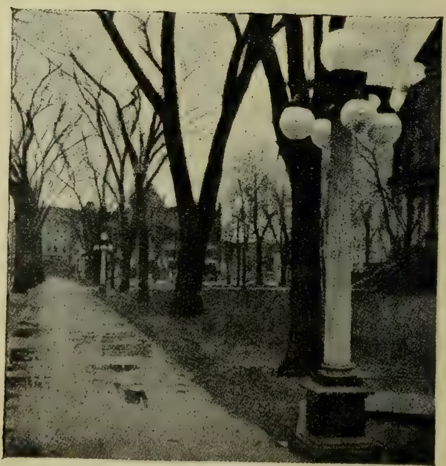
[6] Moll, 'Dissertatim,' Utrecht 1907.

[7] Paschen, *Ann. der Phys.* (4) 27, p. 537, 1908.

(*To be continued.*)

The Illumination of Avenues in Parks by Holophane-Tungsten Units.

THE accompanying illustration shows a method of lighting public squares and avenues in parks, &c., which has recently found favour in the United States. Each column supports several Holophane spheres. The sphere at the top is 40 inches in diameter, and lighted by a 100-watt Mazda lamp. The four 12-inch Holophane spheres below this each contain a 60-watt lamp of the same kind.



The essential feature of this method of lighting is that a very satisfactory and uniform ground illumination is produced, and the intrinsic brilliancy of the source is also very considerably reduced.

The Determination of Mean Spherical Candle-Power.

By an Engineering Correspondent.

(*Continued from p.* 34.)

The Russell Léonard Photometer.

Developed by A. Russell* in England, and Léonard in America. The Matthews photometer is so designed that the angular distance between each pair of mirrors is the same, with the result that the horizontal portions of the polar curve are not so accurately allowed for as those more nearly vertical. Hence Russell places his mirrors at the centre of zones all having the same surface in the sphere, with the result that the same degree of accuracy is obtained with a much smaller number of mirrors.

The best positions of the mirrors are found as follows, to take a particular case :—

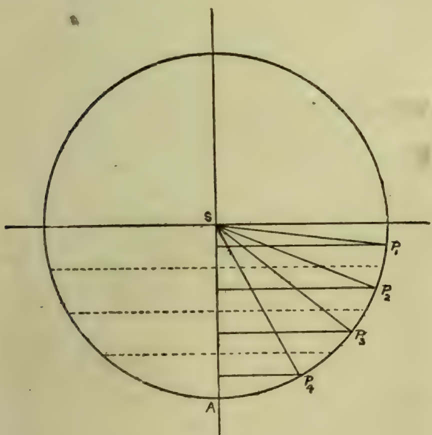


Fig. 6.

Divide the surface of a sphere described round the source into eight equal zones ; these zones will all be of the same height and hence will divide the vertical diameter into eight equal parts.

Through the centres of these parts draw perpendiculars meeting the surface in P_1 P_2 P_3, &c.

Then we may assume that the candle powers in the directions SP_1, SP_2, SP_3, &c., are all equally important.

Hence

$$\text{M.S.C.P.} = \frac{r_1 + r_2 + r_3 + - - - - + r_8}{8}$$

where the r's are the intensities in the corresponding directions.

The appropriate angles at which the mirrors should be placed are given by : $\sin\theta_1 = \frac{1}{8}$, $\sin\theta_2 = \frac{3}{8}$, $\sin\theta_3 = \frac{5}{8}$, $\sin\theta_4 = \frac{7}{8}$, corresponding to angles 7·2°, 22°, 38·7°, 61°.

For all practical purposes ten mirrors are sufficient, the angles then being 5·7°, 17·5°, 30°, 44·4°, and 64·2° above and below the horizontal.

In the actual photometer used in practice the alternate mirrors are placed in opposite quadrants in order to reduce the diameter of the apparatus.

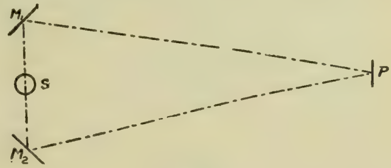


Fig. 7.

Fig. 7 shows the arrangement of one set of mirrors, S being the source, M_1M_2 the mirrors and P the photometer screen. P is so far from S that the angle SPM is too small to be taken account of.

The apparatus is compact and simple and the remarks on the Matthews photometer are again applicable to this instrument.

* A. Russell, 'Mean Horizontal and Mean Spherical Candle-Power,' *Proc. Inst. Elec. Eng.*, Vol. XXXII., p. 631.

The Ulbricht Globe Photometer.

The Globe Photometer, introduced some ten years ago by Prof. Ulbricht, is now extensively used in Germany for measuring the mean spherical intensity.* The instrument consists of a large globe, about 1·5 metres diameter, painted inside with a dead white surface and supplied with means of inserting arc lamps and other sources of light. In addition to smaller openings for hand, holes, &c., there is an opening from 4 to 10 cms. in diameter closed by a milk glass screen F (Fig. 8). The brightness of the screen may be measured by comparison with a standard lamp on an ordinary photometric bench, or the screen may be removed and an illumination photometer, such as the Weber, directly applied to the aperture in the globe.

The fact that the interior of the globe is equally illuminated may be thus proved :—

Let I and II (Fig. 9) be two small surfaces of unit area on the interior surface of the sphere, inclined to one another at an angle 2ψ.

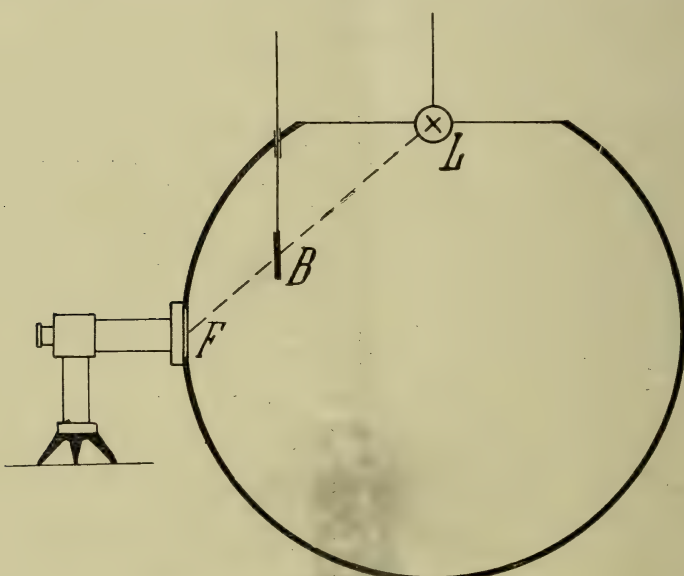


FIG. 8. (*Reproduced from 'The Illuminating Engineer,' Lond., Vol. I., 1908, p. 276.*)

This window is protected from direct light from the source L by a white card screen B, just large enough to effect this result. Under such circumstances the whole of the interior of the globe is of the same brightness and hence the brightness of the milk glass screen mentioned above is proportional to the mean spherical candle-power.

* For an account of this instrument see also Dr. L. Bloch, 'The Globe Photometer in Practical Photometry,' *Illum. Eng.*, Vol. I., p. 274; 'On the Theory of the Globe Photometer, *ibid.*, p. 553; Corsepius on 'Mean Hemispherical Candle-Power,' *ibid.*, p. 801; Sharp and Millar, 'The Integrating Sphere in Industrial Photometry,' *ibid.*, p. 1031.

Let L be the position of the source, and r the radius of the sphere.

I is illuminated from L and receives the luminous flux B, in consequence of which it attains a surface brightness H_1.

As seen from II by diffused light its intensity will be $H_1 \cos \psi$ and as the light from I will be incident on II at an angle $(\frac{\pi}{2}-\psi)$, the intensity of illumination of II due to I will be

$$\frac{H_1 \cos^2 \psi}{S^2} = \frac{H_1 \cos^2 \psi}{4r^2 \cos^2 \psi} = \frac{H_1}{4r^2}$$

being independent of ψ, and hence the same for all parts of the globe.

Hence the globe will be equally

illuminated at all points on its interior surface.

Now let F be the total flux of light emitted from the source L; then, if *a* is the co-efficient of absorption of the coating of the globe, the total flux in the globe due to the successive reflections is

$$F(1-a) + F(1-a)^2 + F(1-a)^3 + --- = F\frac{1-a}{a}$$

Hence the intensity of illumination due to *reflected* light on any element of the interior surface is

$$\frac{F(1-a)}{4\pi r^2 a}$$

It is therefore only necessary to screen some part of the surface from the direct light to obtain an intensity of illumination proportional to the total flux emitted by the source L, this illumination being quite independent of the position of L within the globe.

In using the globe the constant of the instrument must be determined by means of a previously calibrated test lamp. The value of this constant should be checked at frequent intervals to correct for any change in the character of the interior surface of the globe. The coating should be chosen of some material which will not readily darken in colour and which has a good dull matt surface to prevent regular reflections. The opaque screen used to cut off direct light from the observation window should not be larger than is necessary. For glow lamps and similar small sources of light a sphere 1 metre in diametre is sufficient, but for arc lamps enclosed in diffusing

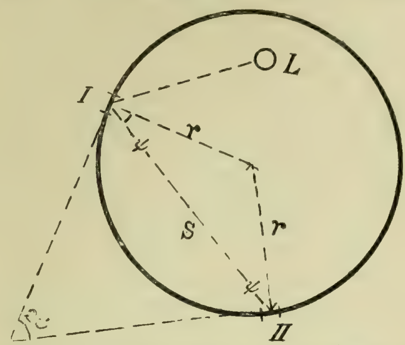


FIG. 9. (*Reproduced from 'The Illuminating Engineer,' Lond., Vol. I., 1908, p. 553.*)

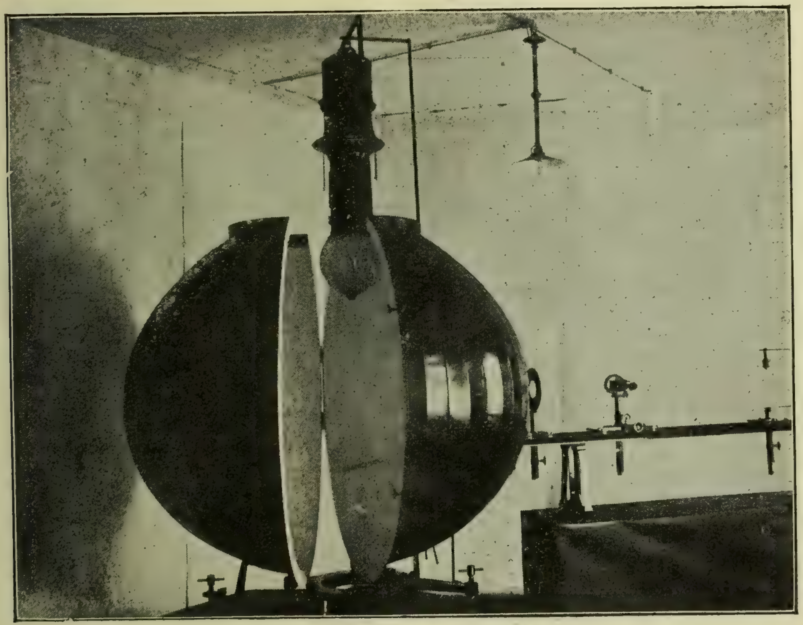


FIG. 10.—The Ulbricht Globe.
(*Reproduced from 'The Illuminating Engineer,' Lond., Vol I., 1908, p. 557.*)

globes, &c., a diameter of 1·5 to 2 metres is necessary for accuracy.

The globe may be used to measure mean hemispherical candle-power by obscuring half the source with a box, black inside and white outside, or by raising the lamp until it is partly inside and partly outside the globe, the plane of the opening in the globe passing through the centre of radiation of the luminous source. The advantages of the Ulbricht sphere are that no darkening of the photometer room is necessary, and that less skill is required in the setting up of the instrument than with the Matthews photometer. Also no rotation of the source is necessary and no trouble is experienced due to the wandering of the arc when testing arc lamps. Its disadvantages are the large amount of room taken up and its unsuitability for obtaining polar curves of the source.

To sum up :—

For experiments on isolated lamps in which the fullest information as to light distribution is required, the point-by-point method combined with one of the graphical constructions described above would be the most suitable.

Where many lamps of the same type are under observation a photometer of the Matthews type will give the most detailed information in the hands of a skilled experimenter, although under commercial conditions the Ulbricht globe would probably prove the more reliable instrument.

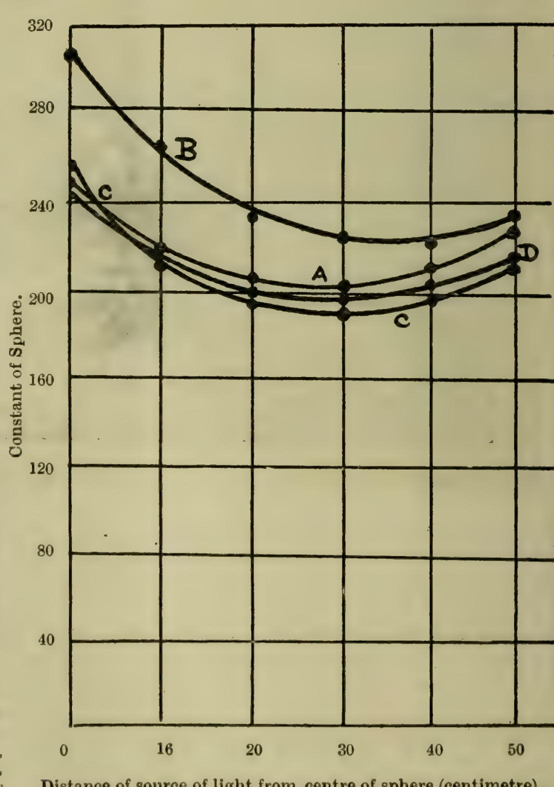
G. B. D.

Experiments on the Ulbricht Globe Photometer.

THE value of the globe photometer for photometrical measurements is now becoming very generally appreciated, and we observe that experiments are now being made in several countries with this apparatus.

A. A. Perrine, for instance, describes, in *The Electrical World*, of New York (September 23rd) some experiments with a globe 120 cms. in diameter, which he employed for testing glow-lamps both with and without reflectors. It is, perhaps, not surprising to find that in such a relatively small globe the constant was found to vary somewhat according to the position of the source tested. The author states that this variation is largely due to the error caused by the necessary introduction of a screen to protect the observation window from the direct rays of the source tested. The possible effect of such screens and other "foreign bodies" on the constant of the globe has already been referred to in this journal (see Vol. I., 1908, p. 555).

The accompanying figure shows some of the results obtained in the experiments to which we now refer.



A. Carbon Filament lamp with reflector, type "A."
B. " " " " " "B."
C. " " " " " "C."
D. " " " " " "D."

The Electric Lighting of Churches.

SOME time ago a special section of *The Illuminating Engineer* was given up to the subject of Church lighting.* On that occasion we pointed out the difference that existed between one church and another, and the need for recognition that the illumination in any case usually presented a separate problem with special difficulties, and special circumstances to be taken into consideration.

Not only have the ordinary requirements of good lighting to be attended to but there are also religious considerations to be borne in mind. It is quite conceivable that a system of illumination that would answer in the Church of England might not be considered satisfactory in a Roman Catholic Cathedral or in one of the Eastern Churches.

It is interesting, therefore, to notice a few instances of churches in Germany to which electric lighting has recently been applied.* Three such churches are shown in Figs. 1, 2, and 3 (for the use of which we are indebted to the courtesy of the A.E.G. Company of Berlin). Fig. 2 represents an important Catholic Church at Neuburg, in which arc-lamps have been installed. This seems to be a rather striking instance of the introduction of high candle-power modern illuminants amid old surroundings, and it will be interesting to see, as years go on, how far the use of such sources will commend itself to architects and others responsible for the artistic aspects of the subject. Illumination by such powerful sources as arclight is, of course, quite a different system from the illumination by the small oil lamps, candles, &c., which tradition has rendered acceptable. Yet it will be recalled that Mr. J. B. Fulton,

FIG. 1.—Ancient Chandelier supplied with Electric Candles, Hildesheim, Germany.

* *The Illuminating Engineer*, Lond., January, 1909.

* *A. E. G. Zeitung*, December, 1909.

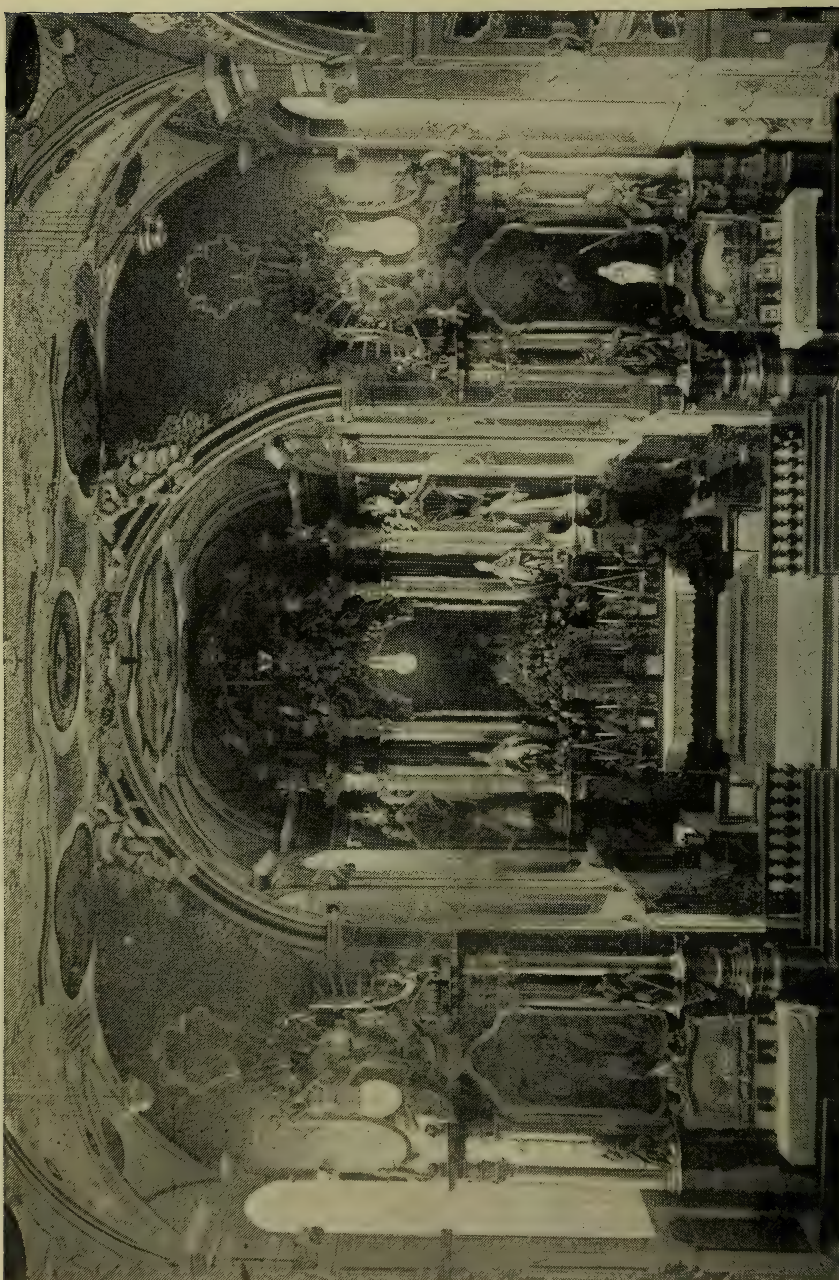


FIG. 2.—Illumination of the Catholic Church at Neuburg, Germany, by Arc-lamps.

in his account of the illumination of the Church of Santa Sophia in Constantinople, suggested the possibility of a powerful light being used in the dome to increase the available illumination.* In this church the existing illumination is provided by large numbers of small oil lamps which, however, serve as decorative objects rather than for the purpose of revealing the surroundings.

A special feature of many systems of church lighting is the use of large numbers of candles. It seems probable that in many case this method came to be regarded as correct largely because the lighting by hand of such candles

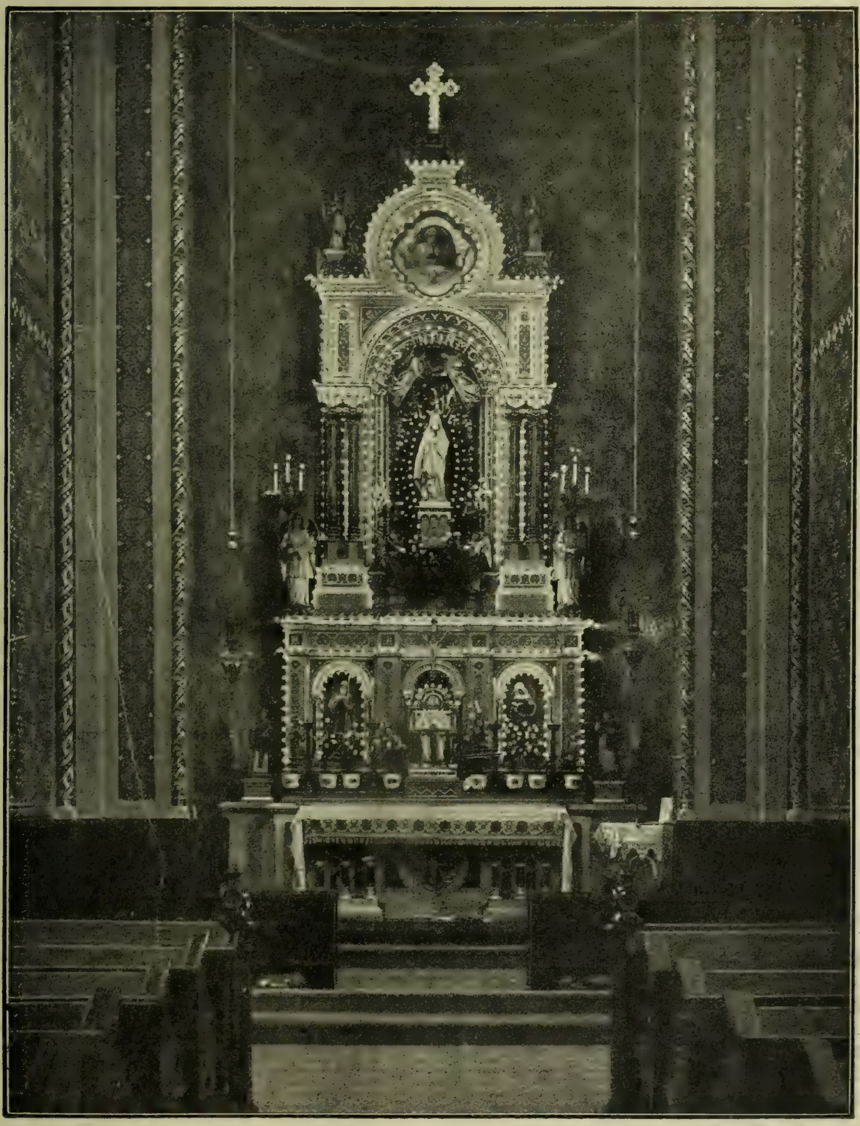


FIG. 3.—Illumination of Altar of Catholic Church at Fillippsdorf, by means of small Metallic Filament Lamps.

* *The Illuminating Engineer*, January, 1909, p. 60.

(though often very tedious in the case of large chandeliers) is to be regarded as an act of worship and a religious observance. We find, however, that it is now becoming customary to replace the candle proper by the electric imitation; in this case the labour of lighting disappears, the whole chandelier being immediately lit up by merely pressing the switch. An illustration of this change is shown in Fig. 1, where a very large and old chandelier, dating from the eleventh century, will be seen in the foreground. Electric light was applied to this old church at Hildesheim in 1906.

Yet another illustration of the provision of electric lighting for decorative purposes is shown in Fig. 3. Here we see the altar of the Catholic Church at Filippsdorf illuminated by large numbers of miniature frosted glow-lamps, supplemented by imitation candles. Electric lighting has also been introduced by the A.E.G. Company into churches of many other denominations, including several synagogues. In addition electric power now fulfills many other functions in connexion with the church such as the control of the organ. In some cases it has even partially replaced hand labour in the ringing of a chime of bells.

The Need for Good Illumination in Schools.

We note in the *Journal für Gasbeleuchtung* (January 8th, 1910) a reference to a paper delivered by Dr. Freitag in Münich before the Verein für Fraueninteressen, dealing with the eyesight of school-children. The author pointed out the vital necessity for good illumination for growing children. This was exemplified in the Gymnasien where as many as 64 per cent. of the scholars were found to suffer from short sight.

The conditions of daylight and artificial illumination in a school-room, formed the most important item to be considered. In addition, good clear type and writing were essential, and the correct position of the body must be maintained. In conclusion, Dr. Freitag suggests that a closer study of the exact factors responsible for short sight is needed in order to remove the imperfect conditions as far as possible. and bring about a desired improvement.

The Psychology of Church Lighting.

In *The Journal* of the Society of Architects for October, 1909, reference is made to the mysticism attaching to Christian tenets and its influence on church lighting. "This," it is remarked, "may be contrasted with what may be termed the 'mystery' connected with some of the more remote faiths wherein the prevalent idea was that the gloom of the temple interior should be in direct ratio to its sanctity. This effect of gloom and mystery was obtained by two methods, if not three; the ancient temple consisted of a congeries of rooms progressively narrower, lower, and more shut off from the light of day as the innermost sanctuary was approached. This could not but result in a tendency towards making a terror of religion, and the hierarchy enhanced this impression on the lower orders by calling to its aid the use of scientific tricks and mechanical subtleties.

"How different from the more modern ideal of concentrating the resources of art and shedding a brilliant light upon the central point of attraction in a place of worship as most effectively seen in the chancel of a church. The soul of religion is not wrapped in mysterious veilings, and the faith of worshippers is invited to satisfy its cravings intelligently, not blindly. The accidental mysticism arising from what has been termed 'dim, religious light' has been perhaps unduly insisted upon, as the feeling is probably the result of environment."

Some Notes on the Present State of the Metallic Filament Lamp.

By an Engineering Correspondent.

The metallic filament lamp has now been sufficiently long in general use to enable a prolonged and fair test to be made on the part of unprejudiced consumers. Although the general characteristics of the lamp, and its methods of application to the usual circumstances of supply are so well known as to render any detailed description on this head unnecessary, there occur from time to time little points in practical experience which may not be generally known, and which may, therefore, be of interest to engineers who have to deal with the problems peculiar to the use of this new source of light.

As is the case with most essential truths it is to be found that the problems involved in the use of metal filament lamps (or their improper use), are really most simple when the cause of the trouble is found, but, as contempt for the simplicity of a remedy was long ago reproved by Columbus in his celebrated illustration of the egg, it is hoped that the simple nature of the following notes may be pardoned, and that they may be of some service to those concerned with the use of these lamps.

One of the points that was raised by those accustomed to the carbon filament lamp, when these metal lamps were introduced to the public, was that the new lamp, although burning quite satisfactorily on even voltages, was hardly to be relied upon when (as is the case with many systems of electricity supply from a central station), the voltage varies within appreciable limits.

This has since been found to be an extreme view. If the earlier types of lamps did burn out with a comparatively slight increase of pressure it was either due to the earlier troubles of insulation in the lamp cap, or to the fact that the makers, in endeavouring to provide a lamp of very high efficiency as compared with the carbon filament, rather overdid the matter, and ran the lamps with two fine a margin as regards over-heating. Now-a-days, however, a good commercial lamp is very well able to take care of itself as regards fluctuations of voltage. As a matter of fact, although it is not a wise thing to do, it is quite possible to place a 50-volt lamp across a 100-volt circuit for a short period. A 16 c.-p. lamp under such circumstances appears like a ball of fire, but although the bulb may become slightly discoloured, the filament, as a rule, does not burn out with the same rapidity as a carbon lamp would, should it be subjected to a like process. There is no doubt, however, that with even a momentary application of an excess of voltage of this order, the filament is seriously weakened, and lamps in series which have been subjected to such a momentary over-voltage due to shortcircuiting of one of their number often give way after about three weeks burning.

That this is no idle statement may be confirmed by the fact that a firm of lamp makers on one occasion actually sent out by mistake a batch of lamps of about half the correct voltage to a customer, and before the mistake was discovered the recipient of the lamps burned them for an entire evening without serious loss. There was, however, a distinct discolouration of the bulbs. Needless to say, the customer was exceedingly gratified with the illuminating effect of the lamps, and was very much disappointed when he received an intimation from the firm that, owing to an oversight, lamps of the wrong voltage had been sent to him. The curious part of the matter is that the lamps having been exchanged for those of the correct voltage, were tested, as a matter of curiosity, upon the proper supply

pressure and were found to be still useful. The value of this point is that at the present time, except where small transformers are used, it is usually the practice to place two or more lamps in series with each other upon the supply voltage. These burn quite correctly so long as nothing happens to any one of the lamps, but should a short circuit occur across one lamp, the others of the series are subjected to undue pressure. It is not argued from the above that it is wise to connect lamps up indiscriminately without pairing them against one another, so as to secure an equal distribution of pressure, but it is wise to emphasise the fact that the metal filament lamp is not quite such a delicate article as some of its earlier opponents would have us believe.

Reference has been made in the above notes to the fact that small transformers are sometimes used for the purpose of reducing voltage from the ordinary supply pressure to that at which the lamps can be most economically manufactured for small units of candle power. This practice is very much in vogue at the present time, but it may be worth while to draw attention to the fact that unless these transformers are equipped with some method of cutting off the primary current when no lamps are alight on the secondary, serious no-load losses may occur. During the early days of the metallic filament lamp boom a number of small consumers in a certain district had trial lamps installed, operated from a small transformer in each case. The average yearly consumption of these people, who, as a general rule, lived in four or five-roomed flats, was about 75 units. Now most of the small transformers, being unprovided with some form of no-load tripping device in the primary, consume about 40 units per year if they are always in circuit, The result in this particular case was that, to the surprise of the consumers concerned, no saving whatever resulted, inasmuch as the transformer losses more than balanced the increased efficiency of the lamps. This is, therefore, a point which should be very carefully watched by supply engineers who are taking a hand in the exploitation of metallic filament lamps.

One of the greatest inconveniences with regard to the use of these lamps is the fragility of the filament, and this, perhaps, more than anything else, may explain why the older type carbon lamp has not been completely superseded. In spite of the fact that it is now fairly known to most consumers that metallic filament lamps may often be repaired, if they unfortunately get broken, by very simple means, distrust in their burning powers still remains, and it would be well for supply engineers to give instructions to their consumers that in the event of a section of the filament breaking it can often be repaired by shaking the lamp gently while it is in circuit. The broken ends, if the shaking succeeds in bringing them together for an instant, will then weld into a fairly permanent joint and the interrupted circuit will be resumed. At the same time, however, in the writer's opinion, this suggestion of excessive fragility has been often exaggerated.

The writer is aware of one case in which a considerable number of one form of tungsten lamp were used for street lamp lighting, as is now becoming customary, in side streets where units of small capacity and lesser current consumption than an arc lamp are necessary. It was feared at first that such lamps would, although effecting a considerable saving in current consumption, nullify this effect by excessive breakages; but this was not found to be the case, and in one instance a 200-volt lamp burned for 4,000 hours in a street lamp. This was accurately determined owing to the fact that the supply authority kept a record of all lamps used for the street lighting. It need not be argued that this is an exceptional case, because metallic filament lamps of all well-known and reputable makes have been known to burn, even in places where a certain amount of vibration is present, such as in substations on electricity supply systems, for over 2,000 hours.

The present position with regard to the fracture of metal filament lamps seems to be that under ordinary circum-

stances they will stand a reasonable amount of vibration without very much harm. Where, however, trouble exists it will probably be traced to some special cause which is removed from the normal conditions under which the lamps should burn. For example, in one case where metal filament lamps were tried for side street lighting instead of the gas-lamps previously employed, it was found that the 200-volt lamps used suffered to a considerable extent from broken filaments. This was traced to vibration of the columns on which the lamp brackets were fixed in high winds, and in order to cure this trouble it was found advisable to allow the lamp holders to hang free on short lengths of flexible wire, instead of being fixed rigidly to the columns. This slight alteration practically ended the trouble. This point is of especial importance in those cases in which side lamps are fixed on tramway columns for the purpose either of giving local lighting effect, or of giving reduced candle-power after midnight. The continual passing of trams tends, of course, to vibrate the columns to a considerable extent, and where the track is not very evenly laid the jolting of the cars over the ends of sections, and especially in negotiating points, communicates vibration to the ground which is transmitted to the pole. By adopting this method of flexible suspension, a large number of lamps may sometimes be saved per annum.

Incidentally, however, it may be mentioned that the use of metal filament lamps for street columns is not altogether an unmixed blessing, for, unless they are securely fastened, they afford a very great temptation to the individual who wishes to raise a little ready money. The use of metallic filament lamps for street lighting has, as a matter of fact, given rise to a new form of stealing. In one supply area quite a large number of these lamps were stolen from street lamps in one night, inflicting considerable losses on the lighting authority of the district. This will be realized when it is remembered that metallic filament lamps of high candle-power cost anything from 7*s*. 6*d*. to 10*s*. each. They are, therefore, well worth stealing, a ready market being presented in connexion with shop lighting. The removal of lamps in this way is made considerably easier by the practice, which appears to be on the increase, of using metallic filament lamps in outside locations without any surrounding lantern. The interposition of a glass screen, however well made, and even when frequently cleaned, leads to a certain loss of light. But this fractional loss is negligible compared to the risk which is run of losing the source of illumination altogether.

After this reference to the danger of breakage of metallic filament lamps, even under proper treatment, consumers' engineers will probably wonder how it is that their experience has been so unfortunate as to include complaints from shopkeepers whose premises are located in main roads, and who have had serious trouble, especially with the 200-volt lamps. The vibration caused by heavy motor traffic, such as is now permitted even in the most congested areas, is sometimes a serious factor. Any one who has observed the tremors which are felt in the vicinity of a roadway when a heavy steam or petrol traction engine is passing need hardly wonder at the fact that filaments sometimes suffer when they are placed in brackets for outside window lighting. The best method of overcoming this difficulty is, either to suspend the lamps on flexible wires, as described above, or, where the lamps are inclined and this method is impossible, to place broad rubber washers at the back of the bracket, or in some other suitable position, so that the earth tremors are taken up by this indiarubber buffer.

There are, however, conditions under which the suspension of lamps on flexible wires does not entirely do away with vibration. The greatest enemy in this connexion is that known as mechanical resonance. Each section of a metal filament lamp, in common with any other semi-rigid body, has a natural period of vibration, and if it is periodically subjected to impulses in the same direction, timed simultaneously with or in multiples of the natural

period of the wire, the swing of the filament will increase until the strain becomes too much for it, and it snaps. A very curious instance of this phenomenon was noticed some little time ago in a basement substation, the floor and ceiling of which were made of concrete, and the station being very solidly built. The attendant in the substation noticed at various intervals a curious and inexplicable flickering ray of light, which proved on examination, to be the moving ray proceeding from a certain filament of a metal lamp. This particular filament—one out of about ten which the lamp contained — vibrated every time a motor bus passed the substation, even though the lamp was hung on flexible wire. The only reason for this appears to be that the impulses derived from the earth tremors produced by the passing of the bus communicated through the concrete ceiling to the lamp a series of impulses which tuned with the natural period of vibration of that particular filament. This caused the wire to vibrate strongly, and had not the matter been detected, would probably in course of time have caused a failure of the lamp. This form of trouble is extremely likely to occur where lamps are fixed on long and slender supports, such as, for example, the curved brackets which are to be found outside the windows of shops carrying lamps for the purpose of throwing a strong surface light on the goods in the window.

Many other interesting points with regard to the behaviour of this comparatively new mode of lighting might be cited, but enough has been said to indicate that in certain particulars the metal filament lamp still requires study, and suffers from exceptional difficulties which are absent from the older carbon filament lamp. No doubt many of the alleged weaknesses of the lamp can be traced in some way or another to incorrect use, while others only require a little further research at the hands of those interested in these problems.

J. A. S.

The Lighting of Streets in America.

Under the above title the *Electrical Times* (October 7th, 1909), draws attention to an interesting development in the United States. For some time it has been customary in certain American cities for the owners of shops in a street to combine together to improve the existing lighting of the thoroughfare.

For example, it is said that in Newark, New Jersey, which is only a few miles from New York, shopkeepers are hampered by the proximity of this city with its tremendous facilities for catering for all tastes and purses. It was felt to be desirable, *firstly*, to stimulate local trade, which might otherwise pass to New York; and, *secondly*, to induce rural shoppers who must pass through the town on their way to New York, to stop at Newark instead of going on to the city.

Eventually a complaining tradesman was approached by a lighting canvasser. He was induced to combine with the adjacent shopkeepers to instal a series of flame arcs and festoons of Tungsten lamps in South Broad Street. As a result Newark to-day boasts an excellent system of curb lighting, not one cent of the cost coming from public funds. The lighting is the result of co-operation between the lighting company and the shopkeepers.

As a result even the improved transit facilities recently effected between New York and New Jersey have brought about no diminution of Newark trade.

Though the shops are closed at night, the streets are thronged. The visitor's first impression is that of a huge holiday crowd. The people are there on pleasure, for the shops are closed; but every succeeding day's trade shows that *light is the tradesman's best friend*.

Illuminating Engineering from the Standpoint of the Gas Engineer.

(Some notes on a paper by Mr. N. Macbeth at the Fourth Annual Meeting of the American Gas Institute, October 20th, 1909.)

A VERY interesting paper by Mr. N. Macbeth was recently read at the fourth annual meeting of the American Gas Institute, and is referred to in *The American Gas Light Journal.*

The key-note of Mr. Macbeth's paper is the suggestion that in future gas and electrical engineers must be prepared more and more to study the needs of the consumer and to teach him how to use the apparatus with which they supply him to the best advantage. In recent years great advances have been made in artificial lighting, and in addition a much higher standard is coming about as regards the *use* of light so produced.

From the standpoint of gas lighting Mr. Macbeth suggests that the gas engineer has great opportunities, but is at present often handicapped by the lack of the necessary information by the aid of which he could expect a material increase as a salesman. Salesmanship alone, however, would not go very far.

Satisfactory supervision and maintenance and attractive fixtures and glass ware are necessary, and above all a thorough study of the installation from the standpoint of effective illumination. In this connexion he quotes the following remarks :—

"We want a new era in gas lighting rather than a pushing of old methods. We need art glassware, well designed, attractive fixtures, new lighting effects, new talking points, a little engineering, something from the decorator, a word from the oculist, substantial construction, convenient devices, and a system of maintenance that will keep the lamps always looking like new. Experts in lighting must be developed, and there is no time like the present to begin."

It would also be for the benefit of the industry, to have established more perfect methods of standardizing the quality of goods turned out. It has often been repeated, but perhaps it has not yet been sufficiently realized, that a good lamp or mantle is always better than a poor one. Cheap and unsatisfactory mantles and burners have a great deal to answer for in leading to erroneous views regarding gas lighting. A need which is particularly keenly experienced is that of a Standardizing Committee for the purpose of creating a specification for incandescent mantles embracing such questions as size, percentage of cerium and thorium, strength, weight, colour of light yielded, &c.

It is pointed out by the author that mantles the light of which only falls by 10 per cent in 1,000 hours ought not to be classified with inferior types which give much the same reduction in only 250 hours, and perhaps as much as 60 per cent in 1,000 hours.

In addition there is room for exact data regarding the effect on the performances of mantles of different pressure and different qualities of gas. A gas burner which shows phenomenal results at one particular pressure in a laboratory test may be of little practical value when used at the variable pressure prevailing in many towns and cities. In this connexion Mr. Macbeth quotes the following figures relating to 825 companies in the United States :—

146 or 17·6 per cent	report between	1 and 2	ins. pressure.
521 or 63·0 per cent	,, ,,	2 and 3	,, ,,
158 or 19·2 per cent	,, ,,	3 and 6	,, ,,

While these figures are not supposed to be extremely accurate, they are probably fairly serviceable as a basis of reasoning. In order to show how vital such variations of pressure may

be, Mr. Macbeth reproduces a series of curves connecting the light and the pressure of various types of burners; he states, for example, that a burner which gave a good result on 1·3 inches was found to give only 50 per cent, of this light when the pressure was increased to 2·8 inches.

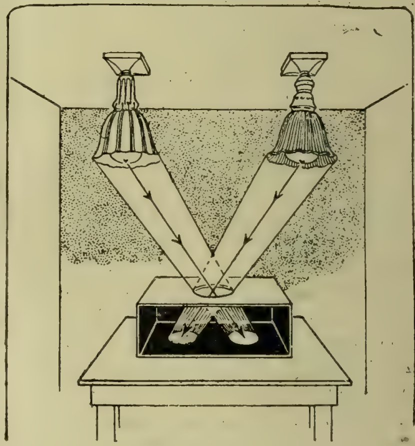
In the second portion of his paper Mr. Macbeth gives a number of rules for the practical illumination of rooms with incandescent burners and reflectors of various kinds; inverted mantles in particular, should be placed fairly high up, both with the object of preventing glare, and also because the curve of the light distribution favours this arrangement. All this is illustrated by photographs showing examples of shops lighted by different methods.

In this connexion Mr. Macbeth gives the following table, illustrating the intensity of illumination required for various purposes:—

Class of Service.	Illumination in Foot-Candles.
1. Store rooms, warehouses, &c. ...	0·5 to 1·5
2. Residence and reading rooms ...	1·0 to 3·0
3. General stores	1·0 to 3·0
4. Dry goods stores	4·0 to 7·0
5. Clothing stores	4·0 to 7·0
6. Detail work tables	5·0 to 15·0
7. Show windows	10·0 to 50·0

The "Lux-Meter."

THE accompanying illustration shows a simple form of apparatus for comparing the effectiveness of different types of shades and lights which has recently been introduced in the United States, and is termed the "Lux-meter." It has been claimed that this arrangement enables a rough idea of the relative value of two fixtures to be quickly formed; they are merely hung at equal distances from the aperture and the relative brightness of the two patches of light is noted; the method, it is said, readily lends itself to purposes of demonstration, which, of course, many forms of more accurate photometrical apparatus do not do.



The "Lux-meter."

In a recent Holophane publication, however, attention is drawn to the fact that such a means of comparison must be used only with certain reservations. It is, for instance, clear that only the intensities of light in one single direction are compared; we are given no information as to the effectiveness of the fixture as a whole. This can only be adequately studied by observations of the total flux of light in each case.

Again, it is pointed out that the arrangement shown gives no information regarding the illumination available immediately underneath the shade which of course it is often very essential to know. Thus a shop-keeper judging solely by the above tests might select a type of reflector which distributed the light uniformly instead of concentrating it, and yet, for his purpose, the latter type of shade might be preferable.

Gas Lighting and Illuminating Engineering.

(Extracts from the Inaugural Address delivered by Mr. H. Kendrick, President of the Manchester District Institution of Gas Engineers, February 26th, 1910).

THE Inaugural Address of the President of the Manchester District Institution of Gas Engineers, Mr. H. Kendrick, was delivered on February 26th, 1910. Mr. Kendrick, who is also a member of the Illuminating Engineering Society, made a number of interesting remarks on illumination, and it is gratifying to notice the importance which he attaches to the study of this subject by the gas engineer. Speaking of the value of the Illuminating Engineering Socety he says :—

"As a mixed Society, it should be neutral ground, where all will receive fair and equitable treatment. That neither gas nor electricity receives it from the other cannot be denied, and statements and claims are continually being made that depend on experiments carried out under perfect conditions in ideal laboratories, and which cannot under ordinary circumstances be attained. When tests are made for public consumption that are founded on results obtained by a process of rejection until the highest or lowest possible readings are reached, can it be surprising that such alarming discrepancies occur between the figures relied on by competing authorities.... We, as engineers, are slowly shaking off the old shackles; and the sharpening of our weapons in the arena of such societies as the Illuminating Engineering Society should be to the benefit of all, and assist us to break through obsolete and, if necessary, modern rules as well....Unless we keep abreast of the times, and do something more than point out how much cheaper and healthier gas lighting is than its rivals, we may be left behind in the race. The electricians are fitting the light to suit the circumstances, and we must do more than merely flood rooms with sometimes superfluous light."

Mr. Kendrick also referred to the illuminating power of various types of good burners, in which connexion he gives the results in Table I. Some of these, it will be noted, refer to coloured globes, and in this case, particularly, we must not forget to bear in mind the amount of reflection from walls of a tinted character. Some remarks were also made upon recent progress in

TABLE I.

Globes, &c., Used.	Best Type of "C" Burner.			Cheap "C" Burner.		
	Gross Candle Power.	Gas Used Per Hour Cubit Feet.	Candle Power per Cubit Feet.	Gross Candle Power.	Gas Used Per Hour Cubit Feet.	Candle Power per Cubit Feet.
No chimney or globe	69·27	3·46	20·02	44·71	3·28	13·71
Straight chimney	74·21	—	21·44	48·17	3·15	15·33
Straight chimney and metal reflector	88·00	—	25·42	57·74	—	18·36
Clear domestic chimney	71·44	3·55	20·12	37·17	2·95	12·59
Clear domestic chimney and opal reflector	92·12	—	25·95	50·49	3·12	16·13
Opaline chimney	61·29	—	17·26	38·87	—	12·44
Opal globe	34·81	—	9·81	26·73	—	8·52
Pale ruby globe frosted	36·56	3·45	10·59	26·31	3·14	8·39
Pale ruby globe cut	45·83	—	13·28	32·46	—	10·34
Pale green globe frosted	44·11	—	12·78	33·22	—	10·56
Pale yellow globe frosted	51·93	—	15·05	36·48	—	11·58

automatic methods of controlling street lighting, the type actuated by a wave of pressure being considered preferable to that driven by clock work, on the following grounds. They are certain in their action; more simultaneous in lighting up; not so liable to be lighted up by vibration; less working parts to get out of order; repairs and cleaning a minimum; first cost usually less; action not dependent on attendant; can light up at any time without sending round the lamp lighter.

As a record of the influence of the type of lantern, &c., on the maintenance of mantles he gives the following table:—

TABLE II.

Type of Lantern and How Secured to Column.	Anti-Vibration Used.	Size of Lantern.	Mantles per Ann.	Means of Lighting.	Remarks.
		In.			
Wind proof, fixed by frog...	Frame	16	4·4	Flash torch	Average of District
Do. do.	None	16	9·3	Controller and by-pass	—
Do. do.	None	16	10·1	Flash torch	—
Good ordinary, not wind proof, fixed by frog ...	Frame	17	12·8	Torch with Hood	Subject to Heavy Traffic Main Road
Do. do.	Spring and Weight	17	20·2	—	—
Cheap ordinary drop doors, loose in head frame ...	None	14	39·7	—	Ordinary Traffic in by-Street
Cheap ordinary drop doors, fastened in head frame ...	None	14	18·0	—	—

Illumination, Natural and Artificial.

On Thursday, March 3rd, Professor Silvanus P. Thompson, D.Sc., F.R.S., delivered the last of his series of lectures on the above subject before the Royal Institution.

The lecturer covered a wide range of subjects. He began by referring to the efficiency of various electric lamps, and presented a table illustrating some of the chief improvements made in recent years. He also pointed out how small was the percentage of energy produced in the form of light by most commercial illuminants, and gave a series of figures by Professor Wedding showing not only their efficiencies, but also the "poison" in the form of carbon di-oxide given out, &c. Finally, something was said on the relative running costs of up-keep of various types of lamps.

The lecturer next turned to the question of distribution of light from various sources, pointing out how necessary it was to obtain photometrical measurements of the light in *all* directions. He also emphasized the need of measurement of intensity of illumination on a surface, and pointed out the need for data regarding the number of foot-candles required for reading, and other purposes. In the study of the illumination of schools, and particularly the daylight illumination, measurements of this kind were much needed.

Prof. Thompson then proceeded to show slides of a number of instruments, including those of Martens, Trotter, Harrison, and others. He also made special reference to the effects of glare from unscreened brilliant illuminants, and showed how this could be prevented by the use of suitably devised globes of the Holophane variety.

In conclusion, he remarked that at present we suffered very acutely from the lack of precise data on matters of illumination. In ten years, or more, no doubt, we should have available much more information as to the result of the researches now being prosecuted, and the Illuminating Engineering Society, which proposed to deal with this matter, had a great deal of useful work before it.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

A New 1 Watt per c.p. Lamp.

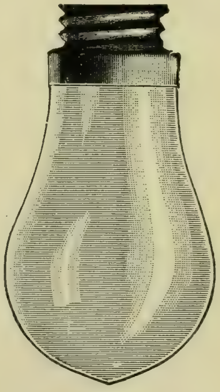
Messrs. Siemens Brothers' Dynamo Works, Lamp Department, at Daltson, inform us that they are about to place upon the market a range of high and low voltage high candle-power metal filament lamps of an efficiency of approximately 1 watt per c.-p. 100 c.-p. lamps will very shortly be on sale, and we learn that lamps of 200, 300, 400, and 600 c.-p. are to be expected at a somewhat later date. We understand that full details will be forthcoming in the course of a week or two, as regards price, size, &c. The new lamp is to be styled the "ONEWATT."

Carbon Filament Lamps for Photographic Purposes.

THE adjoining illustrations refer to a type of carbon filament lamps for photographic purposes, of which we have received particulars from Messrs. **Siemens Bros., Ltd.** (Tyssen Street, Dalston, London, N.E.). The complete lamp (Fig. 1) comprises a cylindrical lamp with clear bulb (Fig. 2) and an outer globe (Fig. 3), which may be of yellow or red glass as required. The design is said to be cheaper than those in which the lamp bulb itself is of coloured glass and the cylindrical lamp inside can be separately renewed. It is also convenient to be able to replace the existing outer cover by one of a different tint when necessary. The glass employed for this outer cover is specially tested spectroscopically with a view to its use in photographic dark rooms.

Half Full Size.
FIG. 1.—Complete Lamp.

Half Full Size.
FIG. 2.—Inner Lamp.



Half Full Size.
FIG. 3.—Outer Globe.

Contracts Closed.

Messrs. **Siemens Bros. Dynamo Works, Ltd.,** inform us that they have secured a large contract for the G.P.O. for Tantalum lamps, and a further large order for street-lighting fittings of special design in South America. Yet another important contract of the same nature secured by the same firm relates to the supply of street-lighting fittings to a municipality in an Indian State.

Messrs. **The Globe Electric Co., Ltd.,** have recently executed a contract for 36 "Multax" long-burning flame lamps for the Bengal-Nagpur Railway Co. More recently another order for 28 lamps has been received from the same quarter.

Robertson & Osram Social and Athletic Club's First Annual Fancy Dress Ball.

The members of the above club had their annual dance on Saturday last, January 8th, when there were about 400 guests. Mrs. C. Wilson presented the prizes. Amongst those present were Mr. C. Wilson, Mr. E. G. Sheppard, Mr. C. Beaven, and Mr. Hill.

Osram Price Lists.

From the **General Electric Co., Ltd.** (71, Queen Victoria Street, E.C.), we receive copies of the most recent lists of Osram lamps. We note that lamps of 25, 32, and 50 H.C.P. can now be supplied for voltages of 200–260, while among the high candle-power units, lamps of 600 and 1,000 candles are now listed for the above range of pressure at a price of 25*s.* and 30*s.* respectively.

Artistic Electric Light Fittings, &c.

From the **Edison & Swan Electric Light Co., Ltd.** (Queen Street, London, E.C.) we have received the most recent catalogue of electric light fittings of all varieties; also particulars of "Ediswan" measuring instruments, recording meters, and testing sets.

New Telephone Address.

Messrs. **Siemens Bros. Dynamo Works, Ltd.,** also draw our attention to the fact that it has been found desirable to instal an additional telephone line. There are therefore now four lines available, viz., 8387, 8388, and 8389 Central, and Dalston 4.

Northampton Polytechnic Institute, Clerkenwell, London, E.C.

Appointment of Associate-Head of the Electrical Engineering and Applied Physics Department.

The above appointment was rendered vacant by the resignation fo Dr. C. V. Drysdale, who has been on the staff of the Institute since its opening in 1896, first as Chief Assistant, afterwards as Associate-Head of the department. Dr. Drysdale's valuable work at the Institute during this period is well known; he was one of the earliest supporters of the Illuminating Engineering Society in this country, and has done much to forward the study of illumination.

Mr. F. M. Denton, of the Carnegie Technical Schools, Pittsburgh, has been appointed to the vacant post. Mr. Denton received his technical training at the Central Technical College of the City and Guilds of London Institute. He has also spent a year and a half in the instrument works of Messrs. Elliott Bros., London, and subsequently was for two and a half years at the Oerlikon Works in Switzerland. He afterwards occupied a position on the staff of the Central Technical College for one year. Subsequently he joined the staff of the General Electric Company in various departments at Pittsfield, Mass., and at Schenectady. After occupying these positions for one year, he was, two and a half years ago, appointed lecturer in electrical engineering at the new Carnegie Technical Schools at Pittsburgh, a position which he still occupies and is resigning to take up his London appointment.

The Imperial Acetylene Hand Lamps.

We have just received from **Imperial Light Limited** (132, Victoria Street, S.W.), some particulars of the Acetylene Hand Lamps, manufactured by this firm, the general nature of which will be gathered from the adjoining illustrations.

The use of acetylene lamps in mines has recently received attention in this journal (*Illuminating Engineer*, January, 1910, page 42). The lamps now referred to, are stated to be particularly suitable for the night inspection of railway companies and water works, &c., and it is also claimed that the lamp gives a very powerful and steady flame, is very light and simple in construction, and will give

50 candle-power for five hours at the cost of less than a farthing per hour. The lamp is equipped with a reflector (shown in Fig. 1) by which the light can be thrown in any desired direction.

New "Tantalum" Focussing Lamp.

It has been often remarked that the end-on Candle Power of the new Metallic Filament Lamps is decidedly weak whilst a good *horizontal* Candle Power is always maintained. Messrs. Siemens Brothers, Tyssen Street, Dalston, London, N.E., are now placing upon the market a new type of lamp which will be known as the "Tantalum" Focussing Lamp, which has an entirely new arrangement of filament by which a maximum end-on candle-power is obtained. The spider on which the filament is wound is constructed in a conical shape, the cone pointing downwards. The special feature of this lamp is that it distributes the light very evenly except towards the cap of the lamp where the light is not required. These lamps are now being supplied for 100-130 volt circuits in 25 c.p. sizes in spherical bulbs measuring approximately 75 m/m diameter. They are especially suited for places where it is desired to obtain a strong and even light without the aid of special reflectors, and should prove useful for stage lighting, ceiling lighting, and decorative purposes, and are listed at the price of 3*s*. each.

Robertson and Osram Lamps for Wimbledon.

We are informed that **The General Electric Co., Ltd.,** have just been successful in obtaining a contract for the supply of "Osram" lamps to the U.D.C. Wimbledon Electricity Department, which includes a large quantity of 200 and 300 c.-p. Osram lamps for street lighting, as a result of the successful experiments which have been carried out with high candle-power Osram lamps in that locality. The General Electric Co., Ltd., have also succeeded in obtaining a contract for the supply of Robertson lamps to the Wimbledon Electricity Supply for the forthcoming twelve months.

REVIEWS OF BOOKS.

The Practical Electrician's Pocket Book and Diary for 1910.

Edited by H. T. Crewe, M.I.Mech.E.

S. Rentell & Co., Ltd., 36, Maiden Lane, Strand, W.C., London, price 1s. cloth, 1s. 6d. leather.

The revised edition of this little book again contains a great deal of information in an easily accessible and tabulated form on a wide variety of subjects. We understand that the different sections are written by specialists in their respective departments, such matters as gas, oil and petrol engines, polyphase machinery incandescent lamps, wiring systems, &c., receiving treatment.

The sections of greatest interest to us are those relating to electric lighting and wiring. We note that the general account of electric lamps is brought up to date by a reference to the most recent types of flame arclamps, miniature arclamps, vapour lamps, &c. We are glad to note that, in dealing with the relative costs of gas and electricity for lighting, stress is laid upon the importance of local conditions and the fact that many other factors, apart from cost, determine the choice of an illuminant. Reference is also made to the importance of the wise selection of shades for use with electric lamps. The section dealing briefly with wiring matters also deserves commendation and the account of methods of enabling lamps to be switched on from several alternative positions, night-switching, &c., will be found useful.

The book concludes with a series of memoranda and tables, and diary. It is intended to appeal primarily to the engineer who requires information in a condensed form at short notice—a purpose which it will no doubt fulfil.

Publications Received.*

Rechentafeln für Beleuchtungstechniker, by W. Bertelsmann (Verlag von Ferdinand Enke, Stuttgart, Germany), a series of tables for assisting the calculation of illumination, &c.

Gesetze, Erlässe, Gutachten und Entscheidungen, in Bezug auf die gesamte Installationsbranche. (Published by the *Oesterr-Ungar Installateur*, Vienna.)

The Sixth Annual Report of the Deutsches Museum at Munich. (R. Oldenbourg, Munich.)

Catalogue du Cabinet Numismatique de la Fondation Teyler à Harlem. (Holland.)

We have also to acknowledge the receipt of, among others, the following journals:—*American Chemical Journal, Transactions of the Am. Electrochemical Society, Proceedings of the Am. Institute of Elec. Engineers, and the Am. Philosophical Society, Transactions of the Faraday Society, Journal of the Franklin Institute, Journal of the Institution of Elec. Engineers (London), Physical Review, Journal of the Society of Architects, Journal of the Western Society of Engineers.*

* To some of these publications we hope to refer in greater detail shortly.

Heating and Ventilation.

The Royal Sanitary Institute have appointed Prof. Henry Adams, of the firm of Henry Adams & Son, and Dr. Louis C. Parkes as their representatives upon a joint Committee which is being formed by the Institution of Heating and Ventilating Engineers to consider the question of legislation in connection with the ventilation of public buildings.

Review of the Technical Press.

ILLUMINATION.

In the British technical press there have been many references to the recent discussion of the Illuminating Engineering Society on the 'Measurement of Light and Illumination,' and Professor S. P. Thompson's recent lectures before the Royal Institution also receive comment. Several journals of the United States also refer to the previous discussion of the Society on the subject of 'Glare,' and **Dr. K. Stockhausen's** serial article on the same subject is concluded in the *Zeitschrift für Beleuchtungswesen* (February 21st and 28th, and March 10th).

Among other articles of a general nature special reference should also be made to that by **E. L. Elliott** on 'The Year's Progress in Illuminating Engineering,' in the first number of the new volume of the American *Illuminating Engineer*. This journal also contains a series of expressions of opinion from experts of all classes in the United States, who state that the progress in their respective fields has been invariably satisfactory; this, it is suggested, is largely due to the Illuminating Engineering movement. Another article by E. L. Elliott deals with Fixture Design from the artistic standpoint. It is pointed out that satisfactory æsthetic design must always be accompanied by good mechanical qualities. A fixture which appears "weak," in the sense that it is liable to snap off or break, is usually also weak in the artistic sense. **R. Bernoulli** also comments upon the artistic side of illumination, showing how very large fixtures must necessarily be employed in large rooms of a certain period so as to be in harmony with the general scheme of decoration.

Another article of a general nature is that entitled 'The Meaning of Illuminating Engineering' (*Electrical Field*, March, 1910). The author gives a summary of the considerations on which is founded the recognized need for special attention to illumination, and also for a wide view of all its aspects, such as the Illuminating Engineering Society seeks to promote.

Special reference may also be made to an article by **G. H. Stickney** (*Elec. Rev.* N.Y., Feb. 26th) on the Illumination of Industrial Plants. The author calls attention to several difficulties in factory lighting, including the obstruction of moving belts, &c., and the tendency towards flicker and travelling shadows. This often necessitates local illumination in preference to a general system. Mr Stickney also points out that it is usually impossible to prescribe a certain number of foot-candles for all classes of work. For example, some experiments on the illumination of targets used on a 220-yard range near a rifle factory showed that the artificial illumination as high as 25 to 35 candles was needed to secure the best light; yet for reading this value might rightly be regarded as excessive.

P. Högner (*E.T.Z.*, March 10th), describes a series of graphical constructions relating to the calculation of ground illumination from sources of light, assuming a knowledge of their polar curves of light-distribution. He points out the difficulty and labour involved in working out the mean illumination in each case and thinks that the work might be simplified if the ratio of the maximum to the minimum illumination were merely ascertained for the comparison of conditions in streets lighted in the same manner.

PHOTOMETRY.

The subject of Photometry formed one of the most important items under discussion at the recent meeting of the Illuminating Engineering Society (London), an account of which will be found elsewhere in this number. The question of Photometric standards was raised by Dr. J. A. Fleming, and commented upon in a recent number of the *Electrician*.

The Flicker Photometer again comes in for considerable discussion. **J. S. Dow** (*Electrical World*, N.Y., Feb. 24th) gives some account of the Physiological Factors which may underlie the behaviour of these instruments, and may cause them to give different results from those attainable with photometers of the ordinary variety.

D. E. Rice in the same journal also deals with colour photometry. He describes experiments with some flicker apparatus of the Rood type, in which he utilizes different coloured papers. He finds that when red is compared, say, with green, and also with white, the relation between green and white, deduced from these experiments, agrees with that actually found afterwards. This he regards as

evidence in favour of the correctness of the use of flicker.

H. Morris Airey (*Journal of the Institute of Electric Engineers,* Feb., 1910) also discusses the flicker photometer. He refers to some researches which suggest that the rate of dying away of the luminous sensation is not the same in the case of different colours; this may lead to peculiarities in the behaviour of flicker photometers when they are to compare heterochromatic sources of light.

Among other articles we may refer to that entitled 'THE RATING OF ARTIFICIAL LIGHT SOURCES' in a recent number of *The Journal of Gas Lighting.* After examining the case in favour of mean spherical candle-power as a means of comparing different illuminants, the writer appears inclined, for practical reasons, to prefer measurement in the direction of the greatest candle-power.

E. Presser (*E.T.Z.*, Feb.24th) points out that, although the peculiarities of the selenium cell render it a very uncertain means of measuring intensity of light *absolutely*, yet it can be effectually used for relative measurements. He describes the use of such a cell in examining fluctuations in the light of various arc lamps, and gives diagrams illustrating its value in this connexion. It is interesting to recall that W. Voege* not long ago undertook a series of researches having for their object the demonstration of the value of the thermopile for measurements of this class.

ELECTRIC LIGHTING.

There are not a great number of articles on electric lighting to record this month.

A paper by **F. H. R. Lavendar**, now published in the *Journal of the Institution of Electrical Engineers* (London), describes a series of life-tests on six different types of metallic filament lamps, and attempts to ascertain the "SMASHING POINT" in each case. It may be mentioned that the lamps apparently give very favourable results; a life of several thousand hours is often attained, although the lamps are stated to be run off the ordinary lighting mains. In the discussion, however, there seemed to be an impression that the "smashing point" was very indefinite, and that in any case it was so difficult to ascertain practically, the exact point when a lamp had fallen in candle-power the given amount, that one could not carry the theoretical results into actual operation.

The use of TUNGSTEN LAMPS FOR STREETLIGHTING seems to be receiving increased attention, and *The Electrician* has an editorial dealing with the matter.

* *Illum. Eng.*, Lond., Vol. I., 1908, p. 239

J. P. King (*Elec. World*, N.Y., Feb. 17th) lays stress on the desirability of not putting too great a weight on the flexible wire actually carrying the current to the lamp; it may, however, be so used when the fixture carried is light. But in any case we must guard against the possibility of the cord becoming frayed on a sharp corner.

Among other articles, attention may be called to the directions for FROSTING AND ETCHING LAMPS in a recent number of *The Electrical Review* of New York. A writer in the *E.T.Z.* comments on the tendency towards REDUCTION IN THE PRICE OF METALLIC FILAMENT LAMPS, and anticipates still further progress in this direction. Other articles, such as that in the *Zeitschrift für Beleuchtungswesen,* deal with the technicalities in the attachment of filaments, &c.

GAS, OIL, ACETYLENE LIGHTING, &c.

A number of recent articles deal with developments in HIGH PRESSURE GAS LIGHTING. Thus **G. Himmel** (*J.f.G.*, Feb. 26th) and **Luber** (*J.f.G.*, Feb. 19th) refer to the various types of fixtures for use with high power hanging sources. The latter makes special reference to the use of suspended high-pressure incandescent lamps in the streets and describes lowering devices, to which the attention of readers of this journal has previously been directed.* In this connection it is also interesting to notice that apparatus of this kind is now being tested in the City of London near Blackfriars Bridge (*J.G.L.*, March 1st).

There has also been a number of general articles reviewing in a general manner progress in gas lighting, in which special reference is made to the IMPORTANCE OF ILLUMINATING ENGINEERING from the standpoint of the gas engineer. This **H. Kendrick** in his Presidential Address before the Manchester District Gas Association (*G.W.*, March 5th, *J.G.L.*, March 1st), comments emphatically on this point and refers to the good work likely to be accomplished by the Illuminating Engineering Society in this country. A comprehensive paper of the progress of the last twelve months by **I. Butterworth** (*Prog. Age*, March 1st) likewise makes reference to this matter and in addition presents a very useful summary on recent developments.

Among other articles we note that of **P. G. Somerville** (*G.W.* March 5th, *J.G.L.*, March 1st) dealing with the NON-COLLODIANISED MANTLE. He points

* *Illum. Eng.*, Lond., Vol. II., 1909, p. 639.

out that such mantles are cheaper, and are also, on account of their pliable nature, excellently adapted for transport, the loss due to breakages being estimated at less than 2 per cent.

T. J. Litle, in a recent paper before the Illuminating Engineering Society in the United States, refers to the CONVENIENCE OF GAS LIGHTING. He lays stress on the value to gas lighting of automatic ignition devices which may enable it to approach the convenience of electric lighting, of being switched off from any point. In this connection he thinks the recently developed pyrophoric system, in which a mixture of cerium and iron is rubbed to produce a spark, may be serviceable. However, he also points out that the present plan of having a bye-pass is not without its advantages during the night. For it sheds a weak light over the room, and thus enables a person, on waking up, to find his way about sufficiently well to turn the light on. In the case of electric lighting he sometimes has to stumble about in order to find the switch, especially if sleeping in a strange room.

Lastly, reference should be made to the Special Convention Number of *Light*, in which a full and illustrated account is given of the recent gathering of the National Commercial Gas Association in the United States.

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MISCELLANEOUS.

Thomson, Sir J. J. Electric Waves and the Electromagnetic Theory of Light (Six Lectures delivered at the Royal Institution, London, on Feb. 12 and succeeding Saturdays, *Electrician*, March 4).

CONTRACTIONS USED.

E. T. Z.—*Elektrotechnische Zeitschrift.*

G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. G. L.—*Journal of Gaslighting.*

J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*

T. I. E. S.—*Transactions of the Illuminating Engineering Society (United States).*

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

·ELECTRICITY· ·ACETYLENE·

The ILLUMINATING ENGINEER

·OIL· ·GAS·

Edited by LEON · GASTER

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EDITORIAL.

The Measurement of Light and Illumination.

THE discussion on this subject, adjourned from the last meeting of the Illuminating Engineering Society on March 15th, was continued on Thursday, April 14th. On this occasion the more practical applications of photometry were considered. A number of forms of Illumination-photometers were exhibited in actual operation, and the proceedings should be influential in helping to establish the impression that the measurement of illumination for practical purposes is, in the hands of experts, a comparatively simple matter.

The Illuminating Engineering movement in this country has now reached a stage at which we should endeavour to collect detailed information regarding the amount of light required under various circumstances. In studying this matter it is of course essential that we should have at our disposal simple and convenient forms of measuring instruments. In practical measurements of this kind we do not so much require to attain the same accuracy as in the laboratory, though we certainly ought to realize the extent of the possible error we may incur. Many of the instruments now available answer the requirements in this respect. We ought, however, to do everything possible to make such an instrument portable and simple to operate, in order that the measurement of illumination may now come to be looked upon as a natural and familiar process. We hope the time is not far distant when any description of the lighting installation of a building will be considered incomplete without a record of actual measurements of the existing illumination.

We should also like to draw attention to the suggestive paper by Dr. W. E. Sumpner, presented at the last meeting of the Society, which will be found in this number on page 323. We have already received

communications from Dr. L. Bloch, Prof. Dr. Ulbricht, and others dealing therewith, and mean to publish these in our next number. Anything that can be done to simplify the existing apparatus for the determination of the total amount of light from a source would assuredly be welcomed, and opportunities should certainly be presented for the bringing forward of suggestions of this kind. During the next session of the Society it is proposed to devote the ordinary monthly meetings of the Society to subjects of general interest such as school-, shop-, library-, and street-lighting, &c., and also to hold more or less informal sectional meetings in between, which would be allotted for the discussion on points of technical interest to certain groups of members. In this way, and also through the formation of Committees, we shall be able to deal effectually with matters of detail as well as to stimulate public interest in general questions of illumination.

Suggested Standard Conditions of Testing Intensity of Illumination.

One of the matters which received special attention at the meeting referred to above was the oft-debated question as to the best method of expressing street- and interior illumination (*i.e.*, whether in a vertical or horizontal plane, &c.). In this connexion we should like to make special reference to a most interesting account of the deliberations of the Sub-Committee on Photometry of the Verband Deutscher Elektrotechniker, some particulars of which we have just received from Dr. L. Bloch, and we propose to give the contents thereof *in extenso* in our next number.

This Sub-Committee have had before them the consideration of the exact terms employed and conditions under which measurements of illumination should be made. They desired to adopt some method which should, if possible, be acceptable both to gas and electrical engineers, and applicable both to external and internal lighting. One of the first items considered was the plane in which measurements should be made. In dealing with this matter they recognize that both horizontal and vertical illumination are important, but, as a result of examining the lighting in the case of a wide variety of streets, they find that the latter is almost invariably very much higher than the former. They consider, therefore, that if the horizontal illumination be adequate the illumination in a vertical plane will also be sufficient. Again, the prevailing tendency in Germany in street-lighting is to place the lamps at a higher level so as to reduce glare to a minimum, and to avoid short lamp-posts. This, it is stated, serves to render the disparity between vertical and horizontal measurement much less marked.

The Sub-Committee therefore recommend tentatively that the specification of horizontal illumination alone is sufficient, the more so as in the majority of buildings, as well as in the streets, it is almost invariably the horizontal illumination, on tables, &c., which is of the greatest consequence. They state further that measurements should be made at the convenient height of 1 metre (3 ft. 4 in.) above the ground or floor, and that the mean, maximum, and minimum values should be given.

As regards the units employed, the illumination is to be expressed in "lux." Specific consumption should be stated in terms of watts for electric lamps or litres of gas per hour in case of gas, per square metre of floor area, and comparisons of different systems of illumination should be made in terms of these quantities.

These suggestions have now been accepted by the Photometrical Committee, and will be brought forward at the annual meeting. It is proposed that they should be adopted provisionally for one year, and any small alterations or additions that may be necessary will be brought up for discussion after

that period. The suggestions have been laid before the Deutscher Verein von Gas- und Wasserfachmännern with the request that they should consider their adoption and suggest any desirable modifications. In conclusion a hope is expressed that all engineers interested in lighting problems will co-operate together to deal with questions of this kind, so as to obtain a common basis of working in measurements of illumination, &c.

It gives us great pleasure to see that our friends in Germany, who have already done so much towards the standardization of photometrical terms and processes, are now taking up the question of actual illumination-measurements in the same way. (Most of the members of this Committee, it may be added, are also members of our Society). This is an excellent illustration of the progress that has been made towards the more scientific treatment of problems in illumination. A few years ago the idea of basing practical comparisons of different systems of lighting upon actual illumination provided might have been considered illusory to a degree. Now we see general agreement not only in principle but even in detail. The matter is one which should commend itself to all those in this country who have the cause of illuminating engineering at heart, and we hope that we shall soon be able to secure similar agreement.

The Public Lighting of Westminster.

We publish elsewhere a reference to the important decision of the Westminster City Council regarding the lighting of the locality round Piccadilly Circus.

There are several points of special interest to us in the arrangements—points which illustrate very forcibly the change in attitude towards the question of public lighting of recent years. It has often been pointed out that any contract for street lighting in which there is no proper safeguard that the illumination will not fall below a specified figure must be considered inadequate. In too many of the contracts of the past there was little or no attention paid to this point, notwithstanding the fact that it is the illumination of the street, simply and solely, for which the public really pay. Now the contract in this case seems to be at least based primarily upon the candle-power of the sources supplied. This is still not the ultimate criterion of good lighting, but it is a step towards the theoretically ideal arrangement of a specified minimum street-illumination.

A second point that deserves reference is the imposition of a penalty of 5*s*. a day in the event of any of the bigger candle-power lamps in the street not giving its certified candle-power, and 6*d*. per day for the smaller units. We do not observe any statement regarding the manner in which this test is to be conducted, nor the fall in candle-power which would be considered a basis for action on the above grounds. But the imposition of a penalty of this kind serves to show the trend of thought on the part of municipal authorities, and will, at least, be considered a step in the right direction.

One other incident in connexion with this recent decision is of interest. A number of shopkeepers in neighbouring streets forwarded a petition to the Council previous to the final decision, emphasizing their claims as large ratepayers and pointing out the importance to them of good illumination of the thoroughfares referred to; they also expressed their preference for an electrical system of lighting. In this case we are not concerned with the question whether their apparent distrust of the proposed change was justified, as they have not yet had an adequate opportunity of making a comparison. But it may be pointed out that their action again serves to show that shopkeepers as a class are becoming alive to the importance of

good lighting in the streets in which their premises are situated.

Factory Lighting.

On Saturday, April 2nd, a lecture on Factory Lighting was delivered by the writer before the Association of Foreman Engineers and Draughtsmen; this was followed by a brisk discussion, an abstract of which will be found on page 336. It is worthy of remark that most of those participating were men holding prominent positions in large works, and therefore, acutely concerned with the problem of factory lighting.

At the end of the evening many of those present confessed that there was a great deal more to be studied in the subject, than they had supposed. Initially, several speakers seemed to be under the impression that a definite general reply could at once be given to the query "What is the best system for lighting factories?" In the discussion which followed, this belief was quite disposed of, and the remarks of several speakers helped to drive home the conviction that it is not only the choice of an illuminant which determines whether the conditions of illumination are efficient and inexpensive, but also, and perhaps even to a greater extent, the way in which the sources of light are used.

A recent article by Mr. L. B. Marks, an abstract of which is also included in this number, provides an excellent illustration of the truth of this remark. In certain weaving mills in the United States a system of local lighting over each loom was provided. It was discovered, however, that over a space of a single loom, about 6 ft., the intensity of illumination at one end proved to be about 100 times that of the other. At one extremity the expenditure of light was extravagant, and at the other the illumination was far too low. By a slight modification a much more uniform arrangement was secured — the range of variation being now only about 2½ to 1, which was considered quite permissible — and conditions provided which were much more satisfactory both to the owners of the mill and the workers.

Problems in Radiation and the Production of Light.

In this number the communication of Dr. W. W. Coblentz on the Distribution of Energy in the Spectra of Artificial Illuminants is completed. This series of articles has contained an exceptionally complete account of the nature of radiation of different sources of light, and will, we hope, lead to some profitable discussion in these columns. As announced when this article was commenced, we shall now be prepared to consider the publication of any comments that our readers may wish to make.

The discussion of these difficult and somewhat abstruse questions may appear to verge on the purely scientific rather than the more practical aspect of illumination. Yet their direct bearing on the production of light cannot be ignored. The estimate which Dr. Coblentz gives for the efficiency of different sources of light shows that our success in this direction has been as yet very modified indeed. Most artificial sources of light produce only a minute portion of the energy given to them in the form of light. The figures quoted by various authorities naturally differ somewhat, but all are agreed that this percentage is very low.

Great as have been the advances of the last few years, it is possible that we are on the eve of yet greater developments. But the time has passed when any progress can be made except as the result of steady, persistent, and scientific efforts. It is quite possible, therefore, that a study of these complex scientific phenomena, abstruse as they appear, may open up the way to great practical developments, and Dr. Coblentz's communication constitutes an excellent summary of the present position and the possibilities of future success.

Leon Gaster.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 295) continues his description of VARIOUS TYPES OF PHOTOMETRICAL INSTRUMENTS. In the present number he gives an account of the instruments due to Weber, and Sharp & Millar respectively. He also deals in some detail with the quality of the screen on which the illumination is received in the latter form of instrument, and gives some diagrams showing the nature of its reflecting power at different angles.

On page 301–324 will be found a complete account of the adjourned discussion on the MEASUREMENT OF LIGHT AND ILLUMINATION at the last meeting of the Illuminating Engineering Society.

Mr. A. P. Trotter describes his form of illumination photometer and gives his experiences regarding the best conditions of measurement in actual practice and the degree of accuracy necessary and obtainable ; this he says need not in any case exceed about 2 per cent., while 5 per cent. is more usual. Mr. Trotter advocates the measurement of illumination in an horizontal plane.

Mr. L. Wild gives his experiences on the question of the sensitiveness of different types of photometers. He gives a table showing the results of testing a number of existing types of screens, and describes several new devices recently used by him with success.

Mr. J. G. Clark refers to the desirability of giving polar curves of light distribution of sources of light as well as their mean spherical and mean hemispherical candle-power. He also refers to the use of the Simmance-Abady street photometer and states that, in many cases, he prefers to measure the candle-power of the source of light from time to time, as a check on the illumination, rather than the illumination itself.

Mr. Haydn T. Harrison describes his form of photometer and confirms Mr. Trotter's suggestion that in street work an accuracy of more than 5 per cent need not be looked for. However, he does not approve of the use of an horizontal screen.

Mr. P. J. Waldram refers to the measurement of daylight illumination and shows how the eye is itself a most unsatisfactory measuring instrument, unless it receives the assistance of special photometrical apparatus.

Following this will be found the communications of a number of corresponding members. **Prof. A. Blondel** describes a number of forms of photometers recently devised and used by himself, and also gives a general summary of the existing methods of determining mean spherical candle-power by the use of such instruments as the "Mesophotometer" and Lumenmeter, &c. ; he also makes a few criticisms on the use of the Ulbricht globe. He is of an opinion that there is no really satisfactory method of comparing sources of light which are radically different in colour, and that the flicker photometer is not to be trusted for this purpose.

Dr. M. Corsepius speaks with approval of the use of tinted screens as a means of bringing the colour of the light from commercial illuminants into better agreement with that of photometrical standards. He also points out the uncertainly that is liable to be induced in comparisons between arc lamps and incandescent glow lamps, owing to the fact that the former are usually rated in terms of means hemispherical and the latter in terms of horizontal candle-power.

Mr. W. J. Cady gives a summary of the best methods of obtaining polar curves of light distribution and quotes some figures showing that the co-efficient of the reflection of mirrors vary somewhat according to the wave length of light. He also refers to the difficulties involved in testing

reflectors; among these is the possibility that different results may be obtained if the distance of the source of light to the reflector is varied.

Mr. A. A. Wohlauer emphasises desirability of comparing different sources of light in terms of the total flux of light produced. **Mr. W. R. Cooper** makes some comments on the question of the detail revealing power of light of different colours, and offers some suggestions regarding a specification for daylight and artificial illumination. **Mr. J. S. Dow** makes some remarks on the sensitiveness of photometers.

Dr. W. W. Coblentz in the present number concludes his communication on The Distribution of Energy in the Spectra of Artificial Illuminants (p. 329). He gives particulars of vacuum tube- and spark- spectra, and concludes by a short summary regarding the luminous efficiency of modern sources of light.

This is followed by a short note on the legal aspects of Shop-window Display. A difficulty experienced by shopkeepers is that any attempt to make their windows attractive is apt to cause a crowd to assemble and thus to bring them within reach of the law; the lighting of the window being one of the most potent means of attracting attention, this subject is of some consequence to those interested in illumination.

Reference may also be made to a note on the recent decision of the Westminster and City Council regarding the Lighting of Piccadilly and the streets in this locality; this was formerly accomplished by arc lamps, but is now to be done by high pressure inverted incandescent gas lamps.

An abstract is published of an address on Factory Lighting delivered by Mr. L. Gaster before the Association of Foremen Engineers and Draughtsmen (p. 335). Some illustrations are also given of factories of various kinds lighted by high pressure gas and flame arclamps respectively. It is pointed out that two chief systems of illumination prevail in factories. Sometimes a general diffused lighting is aimed at: in others local lighting is used. Both have their respective fields. It is, however, essential to provide a system in which the light is sufficiently strong, and to avoid anything in the nature of glare. Flickering shadows must also be prevented. Following will be found a short note on some recent experiences of **Mr. L. B. Marks** in connection with the Illumination of Weaving Mills in the United States. He explains how the illumination over the looms was originally very unequal, being extravagant at one end of the loom and far too weak at the other. By a slight modification a much more uniform and satisfactory result was secured.

On p. 341 will be found a critical article referring to the Lighting of the New South Kensington Museum. The author explains how the conventional official arrangements are in some respects inconvenient as regards planning the illumination and points out some defects in the existing system of lighting.

In the Correspondence Columns **Mr. A. J. Marshall** points out the Value of Illuminating Engineering to the Gas Engineer, and mentions some examples of co-operation in the United States (p. 353). Another correspondent gives a few illustrations of the existence of glare in London (p. 354). He alludes to the glaring effect of the unscreened lamps over the orchestra in certain London Halls, and also to the prejudicial effect of placing naked filaments between the eye and the notice they are intended to illuminate, as exemplified in some of the tube-railways.

At the end will be found the usual Review of the Technical Press (p. 357).

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p. 223, Vol. III.*)

The Weber Photometer.—This instrument was invented by Dr. Leonhard Weber, and described in 1883* as a portable photometer. At an early date it was used in conjunction with a white reflecting screen for measuring illumination, like the first Preece photometer.†

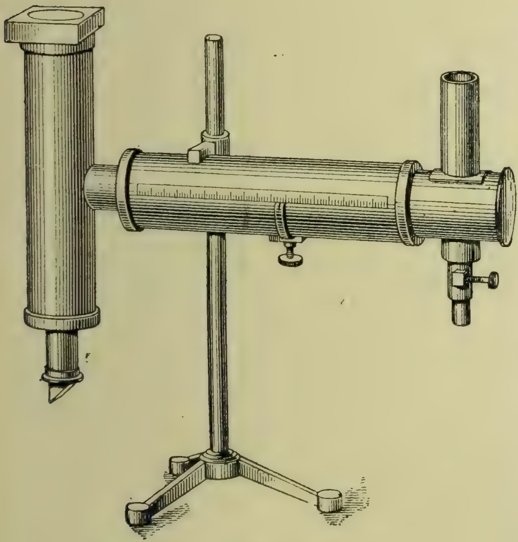

Fig. 114.—The Weber Photometer.

A horizontal tube, Fig. 114, carries a long slender benzine or amyl-acetate lamp at one end, and at the other, a transverse tube which can be inclined at any desired angle.

The transverse tube has an eye-piece at one end, and a disc of opal glass at the other. The eye-piece is provided with a reflecting prism for convenience in use when the transverse tube is pointed upwards. Another disc of opal glass is arranged to move in the horizontal tube. The two discs are viewed and compared by a Lummer-Brodhun double prism. A scale on the horizontal tube allows the position of the moveable screen to be read on a uniformly divided scale.

The Weber photometer arranged for measuring illumination is generally represented with a large white screen set at an angle with it, and a projecting hood or tube to prevent stray light from entering the instrument. This arrangement is shown by dotted lines in Fig. 115. The original use of this instrument with a white reflecting screen was probably due to a greater confidence in the application of the cosine law to the reflecting power of a matt white surface than in its application to a translucent screen of opal glass ; but Mr. Preston S. Millar has shown that when a disc of opal glass is ground on both sides it behaves fairly well, and this being the case, the instrument is suitable for use as an illumination photometer, and offers the valuable feature of commanding an unrestricted view of the whole hemisphere.

The use of a benzine lamp as a sub-standard has been common in Germany; it must be allowed to burn for ten or fifteen minutes before any measurements are made, and the height of the flame must be adjusted with care. This lamp has been found very useful for indoor work, but for street use the modern glow-lamp and battery are undoubtedly much better. It is clear that the range of the instrument is not great, and that for the higher readings, when the moveable screen approaches the source of light, the law of the squares

* Wied. Ann. 20, p. 326, and Palaz. Treatise on Photometry, p. 85.
† Fig. 90, Vol. II., p. 656.

of the distance cannot be depended upon, especially if so large a source as a flame is used. The scale must therefore be calibrated by experiment. The instrument is imperfectly described by Palaz, both in the original work and the translation. Considerable attention is given to it by Stine.* The photometer of Mascart† resembles that of L. Weber in many respects. Good early work on the distribution of illumination was done also with this instrument. The photometer of Blondel and Broca‡ is another instrument in which translucent screens are used. The light is controlled by an iris diaphragm.

The Sharp and Millar Photometer.—After his critical examination§ of all illumination photometers worthy of consideration, and a few others, Mr. Preston S. Millar has designed an instrument in collaboration with Mr. Clayton H. Sharp, and his preparation for the work gives it special interest, for most inventors (with the exception of Mr. Haydn Harrison who has used my photometer and developed a modification for his own special purposes), seem to have given but little attention to the work of others. This was not surprising, for until lately very little has been published on the subject. It is noteworthy that the Sharp and Millar illumination photometer* resembles that of Dr. L. Weber more than any other type.

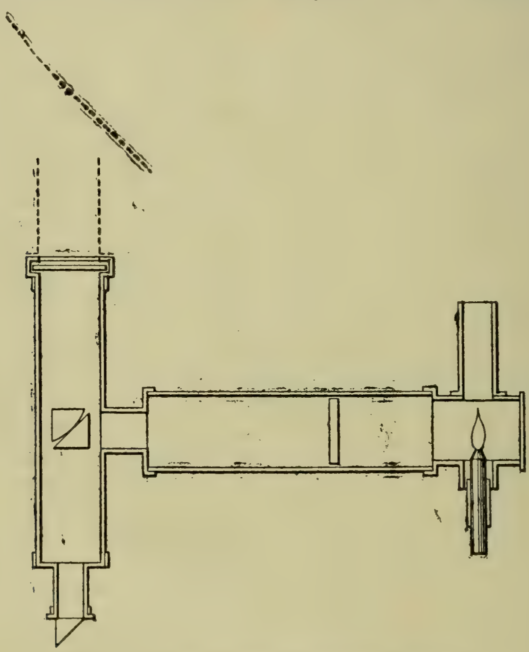

FIG. 115.—The Weber Photometer Section.

The instrument consists of a long box, the exterior is shown in Fig. 116 and the principal parts are illustrated in Fig. 117.

An elbow tube, which, like the transverse tube of the Weber instrument, can be turned and clamped in any direction, is attached to one end of the box. A disc of opal glass ground on each surface, covers the end of the tube.

* Stine. Photometrical Measurements, p. 78.

† Palaz, p. 65. Also P. S. Millar, *The Illuminating Engineer* of New York, Vol. II., p. 481, and *Journal of Gas Lighting*, 1907, p. 632.

‡ P. S. Millar. *The Illuminating Engineer* of New York, Vol. II., p. 479, and *Journal of Gas Lighting*, 1907, p. 634.

§ Millar. Illuminating Engineering Society of Boston, 1907. *The Illuminating Engineer* of New York, Vol. II., p. 475. See *The Illuminating Engineer* (London), Vol. II., p. 727, and *Journal of Gas Lighting*, 1907, p. 630.

* See *The Electrician*, Vol. LX., p. 562, Jan. 24th, 1908.

At the elbow a mirror is fixed. A partition in the box carries another opal screen. This is illuminated by an electric lamp which may be moved by cords and a large handle. The two screens are compared by a Lummer-Brodhun double prism. The principle is therefore identical with that of L. Weber, except that the internal opal screen is fixed, and the lamp is moveable. A translucent celluloid scale allows the shadow of an index to be clearly visible. In order to avoid errors due to reflected light, a number of light diaphragms (not shown in the illustration) are used. The range would be small were it not that two neutral grey glass screens are provided. One of these transmits about 10 and the other about 1 per cent of the light. Since either or both screens may be interposed between the interior opal screen and the double prism, or between that prism and the test plate, the range is largely extended. An adjustable resistance allows the candle-power of the electric lamp to be adjusted so that the scale becomes direct reading.

One of the most important points in such an instrument is the behaviour of the test plate for light falling on it at different angles. The reason why Mr. Millar has used a translucent screen instead of matt white reflector is to enable him to command an unobstructed view of the whole hemisphere facing the test plate, and he achieves this by viewing it from beneath. He has mistrusted the application of the cosine law to matt white reflectors, but it is doubtful whether his test plate presents any advantage in this respect over a good opaque screen. Since the diagram in *The Electrician* giving the departures from the cosine law does not appear to do justice to the screen, I have asked Mr. Millar for the actual results of tests. He has been good enough to send me a specimen test plate, and a curve which is reproduced in Fig. 118. From this I have constructed Fig. 119 for the purpose of comparison with Figs. 103, 104, and 105. Mr. Millar's method of plotting Fig. 118 which gives the error per cent at different angles is the better way of showing the errors at large angles of incidence.

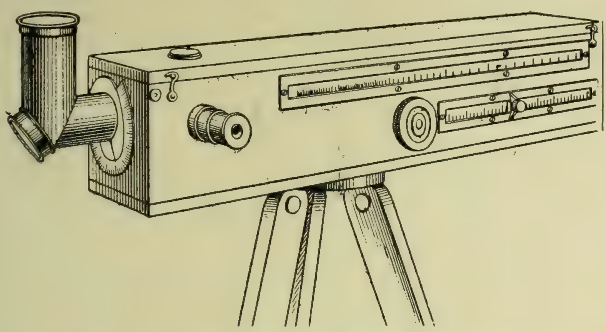

FIG. 116.—The Sharp and Millar Photometer.

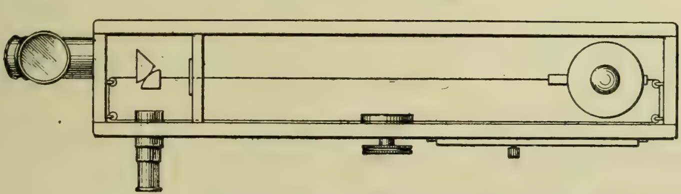

FIG. 117.—The Sharp and Millar Photometer. Section.

This photometer is well adapted for ordinary candle-power measurement, since the elbow tube can be turned in any direction. The inventors claim that the variable distance method has

the great advantage that its indications depend upon a known law, and that consequently a scale can be made from calculation and not as a result of various trials.

Notwithstanding the simplicity of the law of inverse squares, it seems likely that at high illuminations some allowance must be made for error due to the size of the lamp. At the extreme

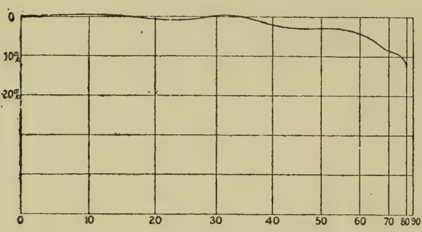

FIG. 118.—Sharp and Millar Test Plate Angle Errors.

right hand end of the scale the distance of the lamp from the opal screen appears to be about twice the length of the filament of the lamp. The right hand end of the scale is very contracted, a small movement of the lamp makes a large difference in the illumination, and unless a plain horse-shoe filament is used, the theoretical position of the lamp must be difficult to settle. It is doubtful whether any portable photometer has ever been constructed which may be relied upon to act according to a theoretical principle. Where an accuracy of ordinary working of 3 or 4 per cent is intended, the scale should be accurate to at least $1\frac{1}{2}$ per cent.

The illumination photometers which have been described have test plates so arranged that light can fall on them from every direction, the observer's body being the only obstruction, and

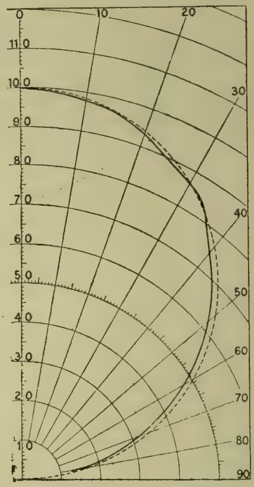

FIG. 119.—Sharp and Millar Test Plate Angle Errors.

even this is avoided in the Sharp and Millar photometer. Another class of instruments intended rather for indoor work, such as measuring the illumination on a desk, have a test plate so situated that the directions from which light can fall on it are limited.

(*To be continued.*)

The "Fondation George Montefiore Levi" Triennial Prize.

OUR attention has been drawn to the fact that the above prize is to be awarded (for the first time) in 1911, subsequent to the international electrical congress to be held in that year. The prize accrues from the interest no a sum of 150,000 francs, and is awarded every third year for an original treatise on recent developments in the scientific and industrial aspects of electricity. The decision rests with a committee which is composed half of Belgian engineers, and half of engineers representing other nations, under the presidency of the Director of the Montefiore Electro-technical Institute. Papers must be received by March 31st, 1911, and may be written either in French or English. All particulars may be obtained from M. le Secretaire-archiviste de la Fondation George Montefiore à l'hotel de l'Association, rue St. Giles, 31, Liége (Belgium).

The Lighting of Westminster.

An important decision has recently been arrived at by the Westminster and City Lighting Committee regarding the illumination of the area of London in the neighbourhood of Piccadilly Circus. In the Circus itself and also in the neighbouring streets of Piccadilly, Pall Mall, Regent Street, St. James's Street, Shaftesbury Avenue, &c., the lighting has hitherto been carried out by electric arc-lamps. By the decision just arrived at they will now be lighted by high-pressure incandescent inverted gas-lamps.

The chief points in the recent history of this locality, as summarised in a recent number of the *Journal of Gas-lighting*, appear to be as follows.

In 1896 a contract was entered into according to which a series of 66 10-ampere arc-lamps, stated to give about 700 candles each, were employed, the cost being 30*l*. per annum per lamp. More recently this cost was reduced very considerably to 17*l*. per annum.

On the expiry of the contract the authorities determined to attempt to raise the standard of illumination, and therefore invited tenders for lamps of higher candle-power. The electric Supply Co. in that area quoted 28*l*. for 3,000 candle-power flame arc-lamps, and 21*l*. for 1,800 candle-power lamps of the same type. The Gas, Light & Coke Co., offered to instal gaslamps of the same nominal candle-power for 22*l*. and 15*l*. 10*s*. respectively; exactly the same existing columns being used for the lamps in both cases.

Meantime a petition was received from the shopkeepers in the neighbourhood protesting aginst the contemplated substitution of gas for electric light. They argued that they paid some of the heaviest rates in the locality, and were, therefore, mainly interested in the system of lighting adopted. The streetlighting Committee were in favour of accepting the offer of the Gas Company, but some members suggested that the decision ought to be postponed until the shopkeepers referred to had had a fuller opportunity of putting their case. Eventually, however, the Council decided to take an immediate decision in the matter, which was as stated. It was also suggested that the shopkeepers would not lose in any way by the scheme of lighting adopted, and that they would be quite satisfied when they had an opportunity of seeing what was actually proposed. It was also contended that the object the Council should bear in mind was mainly the provision of good illumination from the standpoint of the general public and not that of the shopkeepers in the localities concerned. In passing it may be pointed out that, whether their views be correct or not, the action of the shopkeepers is an interesting instance of the growing importance now attached by ratepayers to good illumination.

There is one important feature in the agreement entered into, namely, that a penalty is prescribed in the event of the lamps failing to yield the candle-power promised. Should any lamp be proved to be defective in this respect the Company will be liable to a penalty of 5*s*. per day for large lamps and 6*d*. a day for small ones. It is also interesting to note that the authorities on this occasion, by inviting tenders for lamps of a certain candle-power, recognise the principle that the first item to be considered is the attainment of a certain standard illumination. It is stated that the classification of streets for lighting, with a view to their nature and uses, has yet to be considered.

The Illuminating Engineering Society.

(Founded in London, 1909.)

New Members of the Society.

At the meeting of the Illuminating Engineering Society held at the house of the Royal Society of Arts on April 14th, 1910, the names of the applicants for membership read out at the previous meeting on March 15th were formally approved and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on April 14th :—

Anderson, A. A.	Inspector's Department, South Metropolitan Gas Co., 31, Chevening Road, Westcombe Park, London, S.E.
Bond, C. F.	Inspector's Department, South Metropolitan Gas Co., 86, St. Mary's Road, Peckham, London, S.E.
Briggs, A. S.	Asst. in the Gilbert Arc Lamps Co., Chingford, 5, Westbury Road, Walthamstow.
Fabling, H.	Inspector's Department of the South Met. Gas Co., 76, Manor Road, Brockley, London, S.E.
Ferguson, W., M.I.C.E., M.I.M.E.	Managing Director of the Wellington Gas. Co., 131, Coromandel Street, Wellington, New Zealand.
Harrington, James	Electrical Engineer, President of the London Association of Foremen Engineers and Draughtsmen, 41, Berners Street, Oxford Street, London, W.
Harrop, G.	Director of the Plaissetty Mantle Syndicate, &c., Dermody Road, Lewisham, London, S.E.
Jenner, H.	Manager of Elec. Engineering Dept. of F. Sage & Co., Ltd., 68, Gladstone Avenue, Manor Park, London, E.
Körting, Max	Arc Lamp Manufacturer, Leipzig, Germany.
Mathiesen, W.	,, ,, ,,
Nicholls, M. E.	Chief Indoor Inspector of the South Met. Gas Co., 709, Old Kent Road, London, S.E.
Reiner, J. B.	Optician, 1a, Old Bond Street, London, W.
Ritchie, T. E., *A.M.I.E.E., A.M.I.M.E.*	Chief Departmental Engineer, Lamp Dept., Union Electric Co., 20, Kingston Lane, Teddington.
Schiller, F.	III Hintere Zellamtstr, Vienna, Austria.
Stokes, A.	Chief Outdoor Inspector of the South Met. Gas Co., 709, Old Kent Road, London, S.E.
Sumpner, Dr. W. E., *D.Sc.*	Principal of the Municipal Technical School, Suffolk Street, Birmingham.
Thomas, H. B.	Inspectors' Dept. South Met. Gas Co., 16, Brambledown Road, Wallington, Surrey.

OFFICIAL NOTICE.

DATE OF ANNUAL GENERAL MEETING.

As announced in our last number the **Annual General Meeting** of the Society will take place on **Monday, May 23rd,** at 8 p.m., at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), when it is hoped that all members will make a special effort to be present.

* A list of these names will be found in *The Illuminating Engineer*, April, 1910, page 219.

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Measurement of Light and Illumination.*

(Discussion at a Meeting of the Society held at the House of the Royal Society of Arts (London) on Thursday, April 14th, 1910, and adjourned from the previous meeting on March 15th.)

THE discussion on the above subject, which was opened at the last Meeting of the Illuminating Engineering Society on Tuesday, March 15th, was resumed on Thursday, April 14th, the President, Professor S. P. Thompson, D.Sc., F.R.S., being in the chair. A list of queries bearing on a few points of special interest which had been prepared and circularised previous to these meetings will be found on the opposite page.

The discussion was again a most interesting and successful one. On this occasion the Measurement of Illumination and the practical applications of photometry received most attention. A feature of the meeting was again the exhibition of photometrical apparatus. By the kindess of Mr. C. R. Williams, of the Engineer's Office of the Great Western Railway, a portable street photometer of the Simmance-Abady type was exhibited, and its action was explained in some detail by Mr. J. G. Clark of the Gas Light & Coke Co. Mr. Haydn T. Harrison also showed the most recent development of his illumination photometer. During the course of the evening Mr. Harrison demonstrated the uses of the instrument by measuring the available illumination on the platform due to the existing system of illumination; subsequently the old central gas chandelier which was at one time the chief source of illumination, but is now intended only for ventilation-purposes, was turned on and the measurement of the illumination again taken. This served to illustrate the higher standard of lighting prevailing at the present day.

Mr. A. P. Trotter and Mr. K. Edgcumbe also demonstrated the use of the Universal Illumination Photometer, Mr. P. J. Waldram explained the use of the daylight attachment apparatus utilised with this instrument. Messrs. Everett Edgcumbe & Co. had fitted up a model photometrical bench equipped with their latest type of Flicker photometer. The Martens illumination photometer was also shown in action, and measurements were taken on the table on the platform; the illumination proved to be about 1·5 foot candles.

In opening the proceedings the President called upon the Hon. Secretary to read the minutes of the last meeting, and subsequently to read again the list of names of gentlemen submitted for election at the last meeting of the Society, who would now formally become members.†

The Hon. Secretary next proceeded to read out the names of the following gentlemen which had bene submitted to, and approved by the Council since the last meeting of the Society on March 15th :—Dr. W. E. Sumpner, Messrs. G. Harrop, M. Körting, W. Mathiesen, W. Ferguson, C. F. Bond, A. A. Anderson, A. Stokes, H. Fabling, H. B. Thomas, M. E. Nicholls, H. Jenner, A. S. Briggs, J. Harrington, J. B. Reiner, F. Schiller, T. E. Ritchie.

The President then proceeded to open the discussion, He mentioned that on this occasion the Measurement of Illumination and the more practical applications of the subject would be considered. They had hoped that Sir William Preece, whose work in this field was so well known, would have been able to be present to open the discussion, but unfortunately, by reason of his not very strong health, he had found

† A list of these names will be found in *The Illuminating Engineer* for April, 1910, p. 249.

* Continued from *The Illuminating Engineer*, April, 1910, p. 227. A list of the queries relating to this discussion will also be found on p. 226 in the same number.

himself unable to do so. Mr. A. P. Trotter, however, who had been closely associated with Sir William in the active interest which he had taken for many years in the illumination of streets and spaces was present, and he would call upon him to continue the debate.

Mr. A. P. Trotter, before entering upon the discussion of the Measurement of Illumination formally presented a paper by Dr. W. E. Sumpner dealing with ' The Direct Measurement of the Total Light emitted from a Lamp." (This paper is reproduced in full on page 323).

Mr. Trotter next referred to the remarks at the previous meeting of Mr. Liberty, who suggested that there were too many photometers, and who seemed inclined to wait until the best one had been decided upon. There were many kinds of pens, and many French dictionaries, but nobody put off learning to write or to study French for such reasons. The fact was that photometry, both for illumination and for candle-power, depended very much upon the instrument one was accustomed to. There was no " best " photometer. Any one having practical experience with any fairly good photometer could do almost as good work as any body else, and the more one knew about a particular instrument the better work one could do with it.

The speaker then discussed No. 6 of the queries put forward as the basis of discussion, viz. : " What are the main qualifications of an illumination photometer for practical work ? With what degree of accuracy can the illumination in streets and buildings be measured, and what limits of accuracy should at present be permissible." He considered that the first qualification of an illumination photometer, which in fact distinguished it from a portable candle-power photometer, was the use of a horizontal surface for receiving the illumination to be measured. There had been much controversy on this point. Illumination must be measured upon something which received light from all sources and gave all an equal chance. One of the first essentials therefore of an illumination photometer was a horizontal screen, and one which had no obstructions. There were two or three German instruments —the Martens and the Krüss, and others — which were excellent for measuring light upon a school desk or upon some special place, but these photometers were not adapted for work in streets or railway stations or such places. The second qualification of an illumination photometer was that the receiving surface or test plate should be as matt as possible, that is, should have no appreciable glaze, and should obey the law of cosines as closely as possible, that is, should have no appreciable angle errors. It must be prepared to receive light vertically or at a very large angle of incidence. The third qualification of an illumination photometer was that the portable standard of light should be a good one. The Germans frequently used a benzine flame, which was screwed up until a certain height flame was obtained, but he thought nowadays most people would prefer a little electric lamp and a battery. But these lamps should be checked before and after use. He had had whole evenings' work thrown away by finding a difference of 15 per cent between the test at the beginning and at the end of the work, due probably to loose contacts.

The fourth qualification was a practical range. Many excellent photometers could work with a range of only about 1 to 10, but this was not enough for most purposes. The maximum should be about 4 foot-candles (11·9 to 47·8 Lux (Hefner) ; 10·8 to 43·0 bougie-metres or " international lux ") for ordinary purposes, but there should be some arrangement for increasing the range. The minimum for first-rate street-lighting he should say should certainly reach about ·02 foot-candles (0·24 Lux (Hefner) ; 0·22 bougie-metres or " international lux "). One of the most important things about street-lighting was the minimum. In the City of London this was one-tenth foot-candle, and they should be able to measure well below the minimum so as to obtain a good accurate reading on the minimum, because this was where any dispute would arise. If they could get down to ·01, so much the better. For side streets, small towns,

and places where lamps of 50 or 60 candle-power were used, much of the work would be below ·01 foot-candle. Mr. Voysey, in the City, had measured right down to 5/1000ths.

The fifth qualification was capability for dealing with coloured light. In illumination photometry it was not necessary to attempt extreme accuracy as in the case of standards. Mr. Paterson's work at the National Physical Laboratory dealing with slightly different coloured lights went into fractions of 1 per cent, but for practical work this would be waste of time. They must, however, have some means of dealing with coloured light, and he thought the Abney principle of a freely moving adjustment was the best. The flicker principle was well known, but he had not appreciated it himself. It was his humble opinion that the flicker was very much over-rated: for all ordinary purposes very fair measurement could be obtained without using the flicker. The sixth qualification was a convenient arrangement for measuring the angle of incidence, and the last qualification was portability. Some illumination photometers were wheeled about on carriages. Most were mounted on tripods, all his early work was done with photometers on the ground, but now he preferred holding the instrument in his hands.

Coming to the second half of the question, viz., accuracy, Mr. Trotter said he was sorry that a great many people who had published results of street measurements of illumination had not given their actual readings. They generally gave curves without any readings on them at all, and one had to assume that the readings would have fallen nicely upon the curves if they had been there. In all physical measurements, in which a curve was produced, there should also be the readings. Or at least, a specimen set of readings from which a mean had been calculated should be given, because the differences from the mean were the true test of accuracy. With a good photometer carefully set up in a street with fair conditions, it was possible to get repeat readings within a range of 2 per cent, but was this degree of accuracy worth while for street purposes? Irregularities in globes, or slight dirt on them would make a difference of four or five per cent. Then there was reflected light from buildings and so on. Taking all things into consideration, he thought that a range of between 5 or 6 per cent. was nearer the mark. A variation of $2\frac{1}{2}$ per cent or 3 per cent from the mean should be considered pretty good work. High accuracy was only needed if one had to decide whether the lighting of a street was up to specification.

Mr. Trotter then described his portable illumination photometer, which is made by Messrs. Everett, Edgcumbe & Co.

Mr. L. Wild spoke on the subject of 'The Insensitiveness of Photometers,' and produced the following table which he proceeded to explain as follows :—

INSENSITIVENESS OF PHOTOMETERS.

(Lights of similar colour.)

Type of Photometer.	Equality of Brightness.	Flicker.
	Per cent.	Per cent.
Joly Prism, Paraffin	2·5	—
Simmance Wheel	2·4	1·6
Whitman Sector	2·0	1·0
Inclined Cards	1·2	—
Common Bunsen, viewed one side	1·2	—
Do. viewed both sides	1·5	—
Special Bunsen, viewed one side... (38 lb. Ford)	·4	·8
Do. viewed both sides	·8	·2
Special Bunsen, viewed one side... (60 lb. Ford)	·8	—
Do. viewed both sides	1·2	·4
Lummer	·7	—

The method of test is to take readings in pairs, first moving the carriage from left to right and then from right to left, stopping in each case as soon as balance appears to be obtained. These pairs of settings are repeated at least six times at one sitting, and again on several days, the average difference between settings being taken as the

measure of the insensitiveness of the photometer under test.

The Joly prism comes out worst on the list. This consisted of two paraffin blocks separated by tinfoil. The surfaces viewed were thus not in contact; hence the insensitiveness.

The Simmance wheel when used stationary is practically a Ritchie wedge. Again the surfaces are separated by a thin dark line which is highly detrimental to sensitiveness. When used revolving and as a flicker photometer there is a marked improvement. The non-illuminated edge produces a certain amount of residual flicker which cannot be eliminated and doubtless is detrimental to a certain degree, but not to anything like the same extent as the same photometer used stationary.

The Whitman sector, when used as an equality of brightness photometer, shows no unilluminated edge. The surface of the card in the neighbourhood of the edge suffers a certain amount of damage in the cutting, and this results in the surface becoming patchily illuminated in the immediate neighbourhood of the edge. Everything therefore depends upon the skill with which the sector is cut. This form of photometer again shows up better as a flicker than as an equality of brightness type.

The inclined cards are simply two cards arranged so that the eye looks past the edge of one on to the other. As it is easier to cut a rectangular card than a sector a better result was obtained than with the Whitman. These cards were viewed with one eye only. If viewed with both eyes the balance appeared to change continually, first the back and then the front card appearing the brighter. This is apparently due to the fact that the two eyes see a different portion of the back card, and as the illumination of the cards varies over their surfaces, due to their inclination, there is a continual struggle for mastery between the two eyes.

Another card photometer viewed in the same way, but with both eyes, the surfaces being illuminated by rays striking the surfaces perpendicularly, showed an insensitiveness of ·8 per cent only. This result is not, however, quite comparable, as the same cards were not used, and the cutting may have been performed either better or worse. Probably if the cards could be perfectly cut, this type of photometer, if made of adequate size and viewed with both eyes, would be as sensitive as any.

The common Bunsen disc suffers under several disadvantages. The light from the grease ring is diluted by reflected light. The grease differs in texture and colour to the reflecting portion. The grease either runs into the reflecting portion causing the line of demarkation to become gradual and obscure, or else there is a little hillock of grease at the boundary. The result of all this is that the two portions never melt together into one at the point of balance. The Bunsen is rather less sensitive when viewed both sides than when viewed on one side. It is easier to judge equality of brightness than contrast of brightness when the eye has to travel a considerable distance to make the comparison.

The Special Bunsen (38 lb. Ford) is a great improvement. This is made by dipping Ford's blotting paper of 38 lb. weight in paraffin wax. The wax must be just melting, and the paper must be slowly lowered into the wax and slowly withdrawn again without any pause. The result is a disc half reflecting and half semitransparent. If the operation is carried out with care, the wax is quite evenly taken up, and the line of demarkation between the surfaces is quite sharp and well defined. The wax also penetrates better than in the ordinary process. When this disc is used as a flicker photometer it is less sensitive than as an equality of brightness when viewed on one side. Evidently it is easier to judge equality of brightness when the surfaces are really contiguous than minimum of flicker. When viewed both sides the flicker type shows a marked improvement. One then views both sides, side by side, in a single eyepiece, and instead of balancing to minimum flicker one balances to equality of flicker. Just as it is easier to balance to equality of brightness

than minimum brightness, so it is easier to balance to equality rather than minimum of flicker.

The Special Bunsen (60 lb. Ford) is more insensitive, due to the larger dilution of the light from the translucent surface. This dilution is rather an advantage when dealing with lights of very different colour. It also has the merit or reducing angle error. Turning the thinner Bunson on its pillar through an angle of 1° alters the reading by ·5 per cent. Wi h the thicker disc this is reduced to ·1 per cent. made much larger and viewed with both eyes. In the illustration R R are reflecting surfaces of white glazed paper held between cover glasses. M M M are mirror surfaces. At G G we have clear glass. S S S S are screens. If the reflecting surfaces and side mirrors are made 3 ins. wide and $4\frac{1}{2}$ in. high, and the silvered patch on the front glass is made $\frac{1}{2}$ in. wide and $1\frac{1}{2}$ in. high, and is surrounded by $\frac{1}{2}$ in. of clear glass all round, the picture may be viewed by both eyes at arms' length. The screens are absolutely necessary.

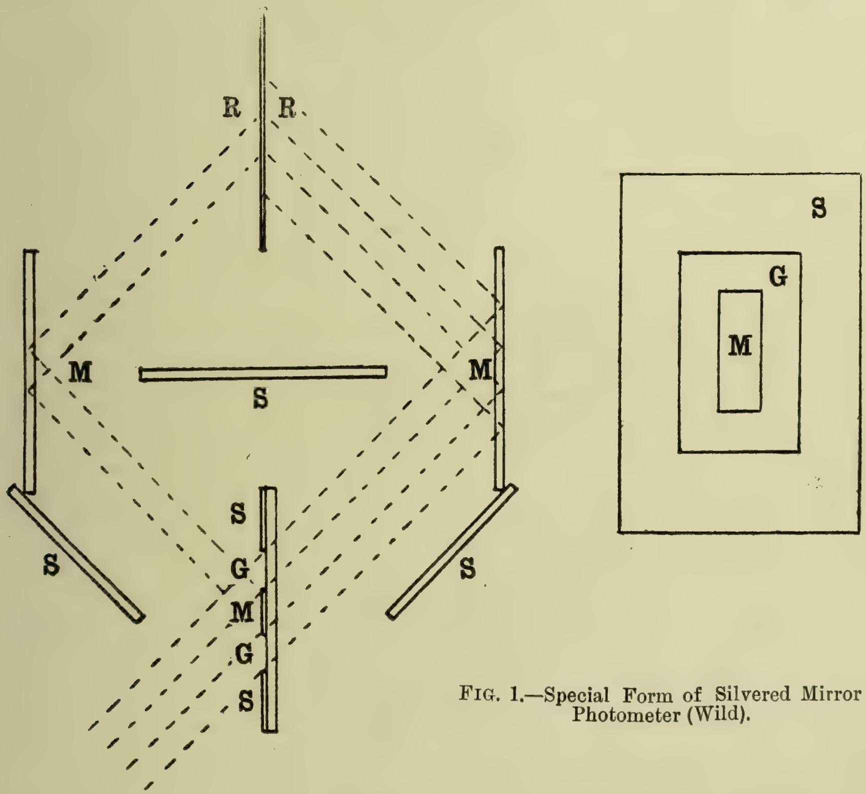

FIG. 1.—Special Form of Silvered Mirror Photometer (Wild).

The Lummer is not so good as the best Bunsen. Substituting for the prisms a mirror silvered on the front with a clear glass pattern in the centre made by removing a portion of the silver, resulted in a very slight improvement. Removing the telescope and viewing with one eye resulted in a further slight improvement. The greatest improvement was made, however, when the whole thing was They prevent the eye being disturbed by catching glimpses of the reflecting surfaces direct. The silver patch can be put on with a very sharp boundary, and when balance is obtained, if there is no difference of colour the two surfaces melt together into one, no texture being apparent in either.

The insensitiveness of this photo meter, as tested by the method men tioned, at first comes out to zero.

That is to say, there may be as much as ·2 per cent. between any two settings, but this is as often negative as positive, and is due to one's inability to move the photometer carriage with sufficient nicety without a micrometer screw. Reducing the size of the picture appears to spoil the sensitiveness.

This photometer has two additional advantages. Freedom from angle error and comfort for the operator. Only if the operator is thoroughly comfortable in every way can he produce the necessary concentration of mind to maintain his accuracy of settings through 2 or 3 hours' work.

The objection to silver on the front of glass is that it requires polishing every day to remove the slight brown tinge due to tarnish. For this reason it is perhaps preferable to view through the glass. This appears to increase the insensitiveness to ·2 per cent.

Mr. J. G. Clark (Gas Light and Coke Co.) said he could not share the bad opinion which some people had of the Bunsen disc. It was part of his duty to keep an eye upon the quality of the mantles which his company used, and for that purpose he found the Bunsen disc a very useful piece of apparatus indeed. He said that horizontal candle-power only is necessary for this purpose. In the first place, one could work for very long periods without fatigue, which was not the case with appliances having optical fittings, such as small telescopes. Further, it permitted adjustments being made whilst one was looking at the screen, which was rather an important matter. Its use, however, is in his experience limited to horizontal measurements.

He very much preferred, in testing lamps, to ascertain the lower hemispherical value, and he mentioned this because a good deal of interest had been displayed recently in connexion with integrating photometers, which permit of the measurements of spherical values by one observation. Whilst it was very nice to be able to take such an important value by one observation, he had come to the conclusion that a complete distribution curve for the lamp was necessary in order to know not only how much light was radiated from it, but also its direction. It was now becoming fairly well recognized that a source of light was a sort of raw material for the lighting business, and having obtained an efficient source of light, it was necessary to consider the best method of distributing it by reflection and other methods. If, therefore, they only knew the spherical value, they were not very much better off than if they had only the horizontal candle-power. They had no data upon which to base calculations or drawings for the design of reflectors and refracting apparatus, so that it was impossible to do anything until they not only knew the total hemispherical value, but also had a complete distribution curve, the latter being by far the most important. It was part of his business to examine a large number of lighting units of different kinds, and he had been considering whether he could adapt the integrating methods, such as the Ulbricht sphere, but he thought the extra time occupied in obtaining a complete distribution curve was well spent. In obtaining these curves he had always used a Simmance-Abady flicker photometer, and he was able to obtain a distribution curve in about an hour, which he did not think was a very long time. In using this apparatus he had come to the conclusion that in practical work the flicker should have a slower speed for a lower illumination. In all photometric measurements it is necessary to approach the point of balance from both sides, and it was very important to have a speed which would bring the two points near together. The Simmance-Abady apparatus is fitted with an adjustable governor, which permits of the necessary regulation being easily made.

With regard to public lighting, his Company had in London several important installations of various kinds, and it was important that they should be maintained at their proper value. He found it convenient to tackle this work on the basis of candle-power. Of course, illumination was highly important and was the thing desired, but when an installation was once fitted up,

and the candle-power of the lamps, the height, and everything adjusted to give a desirable illumination, the candle-power which produced that illumination could be taken as an index of the value from time to time, *i.e.*, if a particular set of lamps giving from 900 to 1,000 candles each was found to produce the desired illumination, then the measurement of that candle-power at periodical intervals would ensure that the illumination was always up to the mark. He found it more convenient to take candle-power measurements in lighting systems of which he knew the relation between the candle-power and illumination. For this purpose he preferred to make the observation at an angle of 30° below the horizon. He used the Simmance-Abady flicker photometer for this purpose and found it a very handy piece of apparatus for outdoor work. Having explained the manner in which he used the apparatus, Mr. Clark said there was one limitation to the instrument for illumination measurements, viz., that it could only take three sides of the lighting, and therefore the best thing to do was to adjust it so that, for illumination measurement, there was the smallest possible light coming in the obscured direction. This applies to all illumination photometers. With an instrument of the Trotter type, one's shadow was always more or less in the way.

As a rule the photometer can be so arranged that the illumination obstructed is a negligible quantity, but special cases may arise where such neglect is not permissible, in which case the difficulty may be overcome by making two independent observations and adding them together.

In measuring illumination it appears on the whole preferable to refer to the horizontal plane. Special cases may arise, as, for instance, shop front lighting, where in general the vertical and normal illumination is of more importance. Another special instance is the lighting of railway carriages, where the objective should be the illumination of a passenger's newspaper or book. The test plane in such a case would be one set at a height and inclination to coincide as nearly as possible with the newspaper.

It had been noted on several occasions that the unsteadiness of the modern arc lamp made precise photometric measurements very difficult. The illumination at a particular place due to an arc lamp might possibly vary between ¼ ft. and 1 ft. candle several times per minute, and he did not know of any photometer which would permit of measurements being made under such conditions with sufficient precision to be made the basis of a lighting specification. What appears to be desirable is a form of integrating photometer—not, however, of the Ulbricht type, which integrates in regard to θ, but one which would integrate in regard to time, *i.e.*, a "Ballistic" photometer.

Mr. Haydn T. Harrison, referring to the question of spherical candle-power, said this was of no use unless they knew how the light was directed. Dealing with the first part of question No. 6, he said the qualifications of a photometer for practical work depended upon what was meant by "practical purposes." He had had to test 150 gas lamps in one evening at an average distance of about 80 yards apart, and therefore a photometer that required five operations to make one measurement would not have been the least use to him. Mr. Trotter had got the acme of simplicity in his photometer, especially as he left the stand behind him, but he was afraid he could not agree with Mr. Trotter on the question of the horizontal screen, and he had abandoned it for general work. If he had to level his photometer for every reading he would never get through 100 gas lamps in an evening, whereas, if he only had to look at a spot on the scale and make a note of the reading, he could.

Mr. Harrison then referred to his own new photometer which is a development of the principle which he used in all his street instruments. When making measurements of street illumination the angle of incidence varied so little from 45° that the cosine did not come into consideration, but with low power lamps, erected 12 ft. high, the illumination half way between

two lanterns was so low that it could not be measured on the horizontal screen. Take, for instance, the usual distance of 60 or 70 yards between gas lamps in side streets, giving about 4 candle-feet direct illumination. But if a horizontal screen were used the angle of incidence was 10 degrees, the cosine of which is ·177. This brought the ·4 candle-feet down to ·08. There were very few photometers that could be worked at such low readings as this. (Mr. Harrison then explained by means of a diagram the method which he employs). In order to get the illumination between two lamps, knowing the angle of one, the minimum ray, he preferred to measure it at a distance where he could measure it accurately. In order to do this, if necessary, he would raise the height of the photometer. This was one reason why he objected to the horizontal screen.

Dealing with the permanency of the standard, Mr. Harrison said he had been carrying out some interesting tests with a small tungsten lamp: he preferred this type of lamp because the variation in candle-power was less than with any other. In his case it had remained constant for over a year within one per cent. Another point was of great advantage, viz., by including a resistance in a tungsten lamp he could reduce the standard down to one-tenth and still remain equally constant, and a fairly good colour. Therefore instead of putting in two lamps into his photometer in order to get a double scale, he only put in one lamp and the plug introduced the necessary resistance to bring the standard down.

He thoroughly agreed with Mr. Trotter's remarks upon the accuracy for street work. He never guaranteed any greater accuracy than 5 per cent. For indoor work, of course, it all depended upon how much time one had to spare. It was possible to work to one per cent., but for illumination work this was an unnecessary degree of accuracy.

An interesting question was No. 8 with reference to daylight photometry. As a matter of fact he should measure the opposite, viz., the dark spots. In a school room, for instance, they chiefly wanted to know whether there were any points illuminated to such a low intensity as to cause injury to the eyesight.

Mr. P. J. Waldram, speaking on question No. 1, suggested that the education of architects was disgracefully neglected in the matter of illumination; in fact, facilities were practically non-existent. A phase of the matter in which he was particularly interested was daylight illumination. This question had not received the attention it deserved: yet it was a most interesting and instructive one if only on account of the way in which it illustrated the weakness of unaided human judgment and personal impression. If the man who said, "Cannot I believe my own eyes?" only knew the absurdities of which the human eye was capable, he would never use the expression again. In photometric work an instrument which was out to the extent of 10 per cent would not be looked upon as a very reliable one, but the human eye could be at fault to the extent of thousands per cent. The strength of light indoors and outdoors on the same day varied by an enormous extent—say 2,000 to 1—but the human eye was almost unconscious of the difference; certainly it could not gauge it to a degree which would be of any practical value. As a matter of fact, the eye was not a measuring instrument and the confident reliance which was commonly placed upon it was absolutely ridiculous. The eye was also capable of hundreds of other fallacies and a study of daylight illumination was a most fascinating subject if for this reason alone.

But it was a more important one on many other grounds. One was the necessity for establishing some standard of daylight illumination of interiors, especially schools. He would like to know Mr. Harrison's standard for estimating the illumination of the dark places in schools; he had not been able to find one yet. The important point was that daylight was constantly changing over a large range to which the eye was almost insensible, which made isolated observations unreliable. Fortunately, however, the illumination

of a room was always a constant proportion of the outside illumination and as such it could be measured very easily.

Mr. Waldram then exhibited an apparatus made by Messrs. Everett Edgcumbe & Co. for this purpose, and which he had largely used.* An ordinary photometer was quite inadequate for measuring the ranges of illumination which occur in daylight. It was unnecessary for illumination photometers for artificial lighting to deal with any greater range than up to 4 or 5 candle-feet, because anything above this was not practical artificial illumination—the eye could not stand it. But with daylight it could easily run up to 800 or 1,000 candle-feet without glare. In the instrument he described there was a tube 10 ins. long, the top of which was closed by one of various diaphragms, placed over the outer screen of a Trotter photometer, the latter being viewed through a side tube. The method of taking the reading of daylight outside was simply to place this tube over the instrument, which would then measure a certain proportion of the light receivable from an unrestricted hemisphere of sky; a proportion determined by the proportion between the aperture used and the arcs of a 10 in. hemisphere, and it could be directly read off on the scale at once. Inside the room the illumination was read off direct without the tube, the ordinary scale reading up to 4 candle-feet, being sufficient for nearly all daylight illumination, at any rate up to June or July. It was found that a yellow screen gave an absolute balance. The operation of measuring daylight illumination of a room—the only correct method—was to measure the *proportion* of the outside light which the room received. This was always constant, and could be measured at any time. The operation was rapid, easy, and essentially accurate—all the classroom in an elementary school could be measured in an hour. The method would not be accurate, however, if the sun were shining into the room or were directly reflected into it.

* For an account of this instrument see *The Illuminating Engineer*, Lond. Vol. I., 1908, p. 811.

A point very often forgotten with regard to daylight illumination was that the critical times were, say, about an hour before and after sunrise and sunset. Between sunrise and sunset daylight illumination increased enormously without the eye being conscious of it. It was at these times that the trouble occurred, and whatever standard were used should bear relation to the time when the measurements were taken, and the state of the sky. It was a curious fact that a blue sky, generally regarded as giving the best illumination, gives nearly the worst—the more cloudy the sky up to a certain point of actual greyness, the better the illumination. He would suggest, as a standard of reasonably good interior daylight illumination, such windows as would give a proportion of 1/1,000th of the outside light. This would be equivalent to an illumination of 1 candle-foot (or a reasonable reading light) at half-an-hour after sunrise and at sunset on any average day.

Mr. K. Edgcumbe joined issue with Mr. Harrison on the question of calculating illumination from the measured candle-power, which was practically what Mr. Harrison's method came to. But reflection from the houses had an important bearing in horizontal illumination, and it was not, therefore, sufficient as Mr. Harrison proposed to measure the candle-power and then calculate what the horiozontal illumination would be. Again Mr. Harrison used a flicker arrangement, and he (the speaker) quite agreed that if a flicker was used it was most important that the screen should be nearly at right angles to the rays for the simple reason that it was a very insensitive instrument at low illuminations. An incidental advantage of one of the *portable* photometers shown that evening and which should not be overlooked, was that, owing to its size it would be very useful in a busy street to take shelter behind as a protection against the traffic.

Mr. Harrison: Has Mr. Edgcumbe ever made any experiments on the effect of reflection from houses in the street?

Mr. Edgcumbe: Yes.

Mr. Harrison : So have I. I take the horizontal readings in the ordinary way and then screen them so as to have only light direct from the lamps on to the screen, and I could not find any difference.

Mr. Edgcumbe : I do not think that is necessarily conclusive.

Mr. Harrison : Well, I think it must be, because, if you eliminate any reflection from the sides of the houses you screen, the effect should be capable of measurement, and this makes the difference.

Mr. Edgcumbe said he had found it almost impossible to screen all "stray" light in this way, in fact, to take a case in point, the question of whether the measurements were being made on a dry or a wet night had an enormous effect on the illumination, and consequently it was extremely difficult to be sure that they were screening all extraneous light.

Mr. Harrison : Surely you do not suggest reflection from the wet road which is below the screen ?

Mr. Edgcumbe : Yes. I cannot fully explain it, but I have noticed it, and it is precisely such unlooked-for discrepancies as this that lead me to say that no assumption should be made and that the horizontal illumination should be measured direct.

Mr. L. Gaster said that the modern tendency was to attach great importance to *measurement*. The value of a measurement of illumination rested largely in the fact that it constituted a record. He, of course, realised that the present systems of determining the intensity of illumination were not perfect and that the instruments of the future might be a great advance upon what he had to deal with now. But he contended that we could already take measurements with quite sufficient exactitude to be of considerable practical value.

As a rule we did not so much care whether the illumination on a table was, say, 3·2 or 3·205 foot-candles. A difference of even 5 to 10 per cent was a small matter. But we did want some instrument by which to ascertain and prove when the illumination was a mere fraction of what it ought to be. If one had no such instrument, and could preserve no record of what the illumination under certain circumstances actually was, one naturally could not substantiate one's impression that the lighting conditions were inadequate. One's conviction in the matter could be put down to personal oddities. But when one could back one's statements by actual figures and determinations it was another matter.

Mr. Gaster said that he, therefore, believed that one of the most important pieces of work for the society to do would be to simplify and popularize measurements of illumination so that they might gradually become familiar and accepted processes. With this end in view the Society had devoted their first session to the discussion of general problems in illumination, and had tried chiefly to bring home the wide range of subjects with which it had to deal. In connexion with the measurement of illumination, one of their chief objects must be, for the present, to interest outsiders connected with all the various trades and professions, and to show them that photometry could be useful to them in their daily life.

There were, of course, a vast number of very interesting questions in connexion with photometry calling for the care and attention of experts in the subject. The Society would proceed to these in good time, and it had been suggested that during the next session the ordinary general meetings of the Society should be again devoted to subjects of a more general interest, but that additional special meetings should take place, if desired, in between, when narrower technical matters could be discussed in detail by those interested specially in these specific points.

In conclusion, Mr. Gaster referred to the improved laboratories which had come into existence and the steady improvement in the standard of photometrical work. There were, for example, the laboratories of the great National Institutions, such as the National Physical Laboratory in this country, the Reichsanstalt in Germany, and the Bureau of Standards in Washington. But other laboratories have

been and were being developed, and he had in mind two at least which were exceptionally well equipped, that of Messrs. Körting & Mathiesen in Berlin, and that of the National Electric Lamp Association, under the charge of Dr. E. P. Hyde, in the United States. He mentioned these two merely to show how commercial men were coming to believe in the value of photometry and the scientific study of problems in illumination generally.

The President, in closing the discussion referred with admiration to the Martens photometer. It was certainly open to the criticism of Mr. Trotter that it could not deal with light in all directions at once, but, after all, so was Mr. Trotter's photometer, for the operator, standing by it, prevented some light from reaching the instrument. Indeed, every photometer which they had seen there was open to the same objection. He noticed that Mr. Harrison stood in such a way that he was intercepting a considerable portion of the light: he certainly did not get the whole light from the room upon the surface, and was it not possible to make an improvement of a small sort in this connection? Why not measure the illumination in two parts? Place the photometer so that it received light only from half the entire horizon from the front and then turn the photometer round and take it from the back.

Mr. Haydn T. Harrison: That is the idea with my apparatus.

The President, continuing, said the difficulty was that one was always apt to get into trouble the moment one began to add up illuminations that were separately measured from different sides. The principles were well enough recognised, but there were always contingent conditions, that they were not perhaps sensitive to at the time, and they might go wrong in the result, but they would not probably go so far wrong as that famous case which came to us from the United States twenty years ago. There was a dispute as to whether a certain arc lamp was giving 1,000 c.-p. The makers said it was, and the people who were using it said it was not anything like so much. The makers sent a man with a photometer and measured on all four sides, 250 in this direction, 250 in that, and so on. He then added them up and got 1,000 c.-p. At the same time he was not sure whether they were taking into account all the elements that they ought to consider when they made separate measurements in different directions and added them together. The question of reflection from the surrounding dull surfaces had not yet been sufficiently explored. Dr. Sumpner's contribution, which had been mentioned, returned to this subject; and it was a subject which might easily occupy a whole evening in discussion. They were now getting to the end of the session. There only remained a general meeting for the election of Council, which he begged to announce. The discussion on the subject of 'The Measurement of Light and Illumination,' now concluded, had been a most fruitful one; and some of the information given would have a permanent value.

Communicated Remarks on the Measurement of Light and Illumination.

Prof. A. Blondel (Paris):—*Query* 1. I consider that the photometrical equipment of our French technical schools, with the exception of the Laboratoire Central d'Electricité, is quite inadequate. There is a lack in some cases, of proper modern apparatus, and in others there is no true conception of the practical value of photometry to engineers.

To be of real utility instruction in photometry ought to be in the hands of engineers interested in lighting, and not exclusively in the hands of physicists in schools of the more purely scientific character. Physicists are

naturally mainly interested only in the more abstruse aspects of the subject, and disposed to ignore its practical possibilities.

Query 2.—In photometrical measurements a precision of ½ per cent is often specified. Personally I have never been able to do better than about 1 per cent. This accuracy, however, is ample for practical requirements and need only be exceeded by those engaged in laboratories where standard work is carried out.

I regard the Lummer Brodhun as a most perfect form of screen giving a very high order of sensitiveness. My friend M. Broca showed, eighteen years

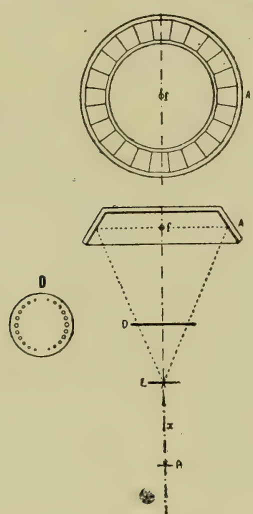

Fig. 1.—Most recent form of Mesophotometer devised by the Author.

ago, how greatly the sensitiveness of photometric instruments depends on the intensity of illumination of the photometer-screen. He pointed out that, in order to secure satisfactory conditions, an illumination of the photometer-screen of at least 10 lux was necessary. Mr. Dow's experiences on this point, referred to in the *Illuminating Engineer* for last month, are in accordance with his conclusions.

Query 3.—The best method of obtaining the polar curve of light-distribution of a source of light is, I believe, the use of "mesophotometers" or mirror integrating apparatus. I described an arrangement of this kind for the first time in 1896,* and the method has been more or less improved by Matthews, Russell, Leonard, &c., since that date. The best system to adopt in such instruments is, in my opinion, to utilise mirrors at regular angular intervals, such as those shown in Fig. 1. This illustration shows the form most recently described by me,† and is constructed, with my authorisation, by Dr. H. Krüss of Hamburg. The advantage of this appliance is that it enables us both to trace out the polar

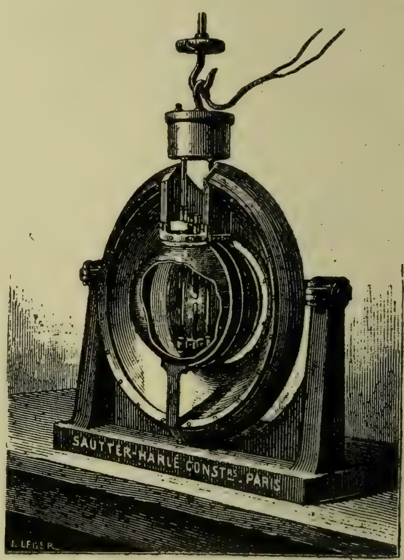

Fig. 2.—Lumen-Meter with elliptic mirror.

curve quickly and easily, and also subsequently to integrate the flux.

Among other forms of apparatus described by me for this purpose, I may mention the "Lumen-meters,"‡

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* *Eclairage Electrique*, 1896, Vol. 8, p. 49.

† *Bulletin de la Société Internationale des Electriciens*, 2nd Series, Vol. 4, p. 39. Fig. 1. Each screen, D, is pierced by an aperture, the sectional area of which is proportional to the size of the angle formed with the vertical. Behind the apertures are a series of lenses which project the images on the screen, E, so that the intensity of illumination may be measured by the photometer.

‡ See the series of articles published by the author on "The Determination of the Mean Spherical Candlepower of Sources of Light," in *l'Eclairage Electrique*, 1895, pp. 385, 406, 538 583.

especially the type utilising elliptical mirrors, which is shown in Fig. 2.

I also approve of the Ulbricht globe-photometer, of which specimens, utilizing two metal hemispheres fitting together, had been already tried by me in 1901. This apparatus is exceedingly convenient for the rapid estimation of the total luminous flux — for example, when it is desired to compare different qualities of arc-lamp carbons. But it has this defect : that it does not also lend itself to determination of polar curves of light-distribution. In addition the calibration of the sphere varies according to the age and nature of the diffusing inner surface, which becomes darker with time. Again, it is difficult to calibrate the larger spheres satisfactorily, owing to there not being available a suitable source of sufficiently high candle-power ; an electric arc-lamp, for example, gives rise to a very uncertain result. Moreover the indications of a globe-photometer are only exact when the diffusing surface and the screen exactly follow the Law of Lambert.*

In any case I do not think the exactitude of the instrument materially exceeds that of the mesophotometer or the Lumenmeter, with the elliptic arrangement usually employed. For the study of naked arcs one can obtain very good result with a conical lumenmeter (also described in 1904).

Query 4.—It appears desirable to express the luminous intensity of sources of light both in lumens and also in terms of mean spherical candle-power so as to suit the respective purposes to which the figures are to be put. For example, the expression in lumens is more convenient when one desires to estimate the mean illumination of the walls of a room.

In addition, it is often serviceable to know the mean lower hemispherical candle-power and flux. Besides these quantities, it is very desirable that the polar curve of light-distribution of a source should be given and the latter cannot be said to be completely defined unless this is done.

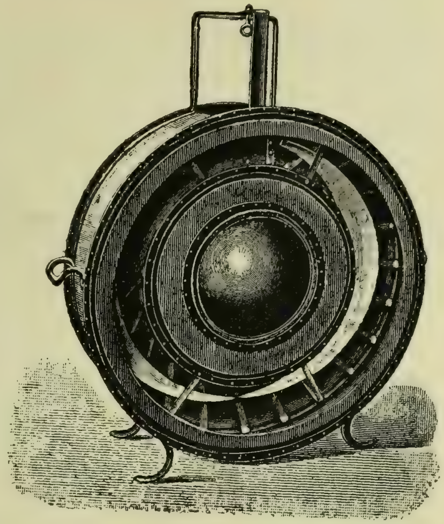
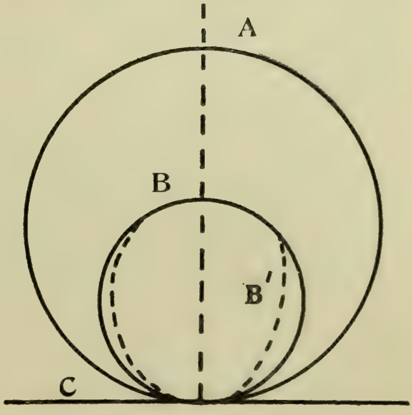


FIG. 3.—Lumen-Meter with diffusing cone.

Query 5.—There is no good method of comparing directly the intensity of sources of light which differ markedly in colour. The flicker method does not depend on any scientific principle, and appears to me to be quite inexact in practice.

I consider it far preferable to make use of coloured screens so as to balance any difference in tint on the part of the sources of light compared ; the recent proposition of Dr. E. P. Hyde, that standards should be issued by the national laboratories equipped with



* If the Law of Lambert is rigidly followed, the illumination of a surface, C, tangential to the sphere A is proportion to the volume of the spherical surface B. But if the diffusion of light does *not* follow this cosine law, the sphere B has to be replaced by a non-spherical body B′, which may give rise to an appreciable error.

certain screens enabling the colour of their light to be brought to the same tint as that of other commercial sources, meets with my entire approval.

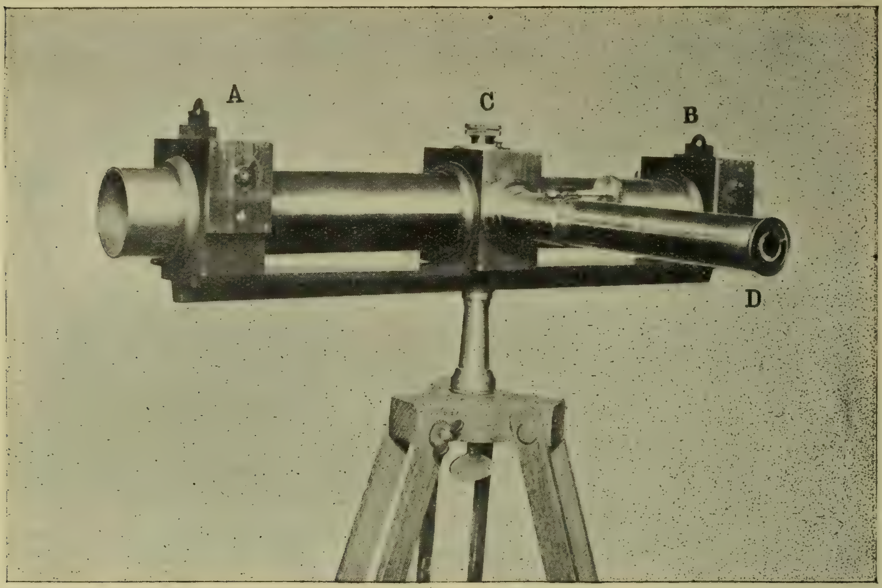


FIG. 4.—Photometer, equipped with "cat's eye" adjustment. A. B. Box containing lenses and diaphragms – C. Box containing prisms and screens — D. Microscope, magnifying power, 50.

Query 6.—Figs. 4, 5, and 6 illustrate three models of photometers which I have constructed during the last few years for the measurement of illumination.* The first-named utilises the "cat's eye" principle, the last two the law of inverse squares. This law appears to me the simplest and most convenient as well as the most exact at present available. The third of the instruments mentioned utilises either a benzene or oil lamp, or a metallic filament. The illumination is varied by a double mirror which can be moved to and fro within the tube. This enables daylight-illumination to be measured as specified in Query 8. The optical part of the arrangements consists in two opal plates A, B, illuminated by the illumination studied and the standard lamp respectively, and viewed by means of the double prism arrangement, C. The appearance of the field of view is also shown in Fig. 7.

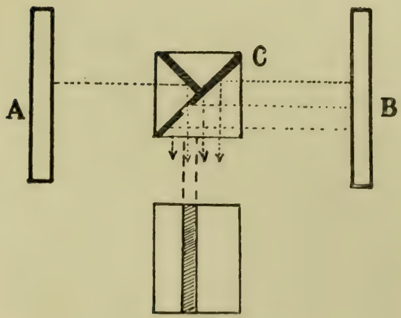


FIG. 7.

For the comparison-light I consider a small benzene or oil lamp, the height of the flame being exactly regulated, preferable to an electric lamp, since the latter requires exact adjustment and involves the additional weight of an accumulator, rheostat, and measuring instrument. I am aware, however, that very compact instruments utilising incandescent lamps have been con-

* These instruments, like my mesophotometers, are constructed by M. Camilleras, 128, Rue du Bois, Levallois, Paris.

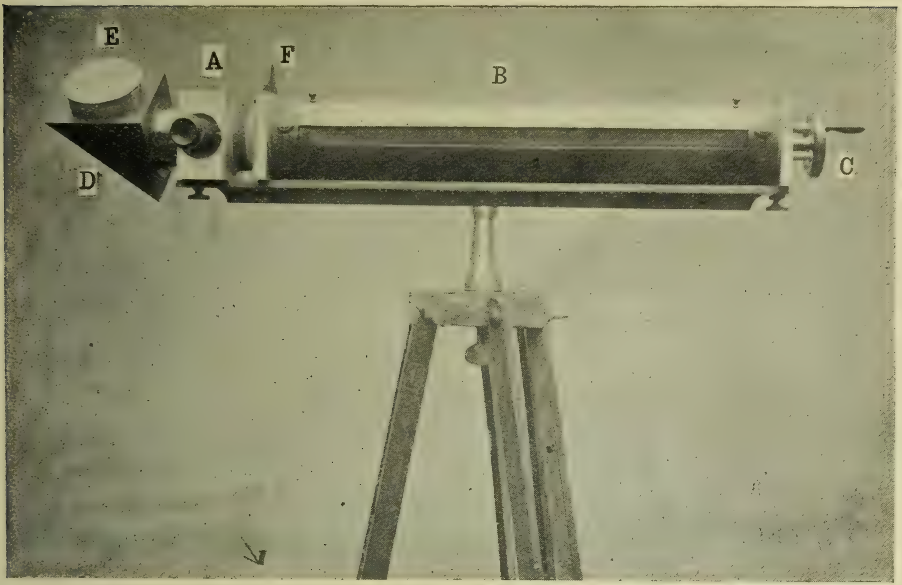


FIG. 5.—Illumination Photometer. A. Box containing prisms and translucent screens—B. Tube containing moveable electric lamp, and stationary scale—C. Apparatus for adjusting and measuring distance of lamp from screen—D. Mirror inclined at 45°—E. Screen to receive illumination at variable angle—F. Diaphragm.

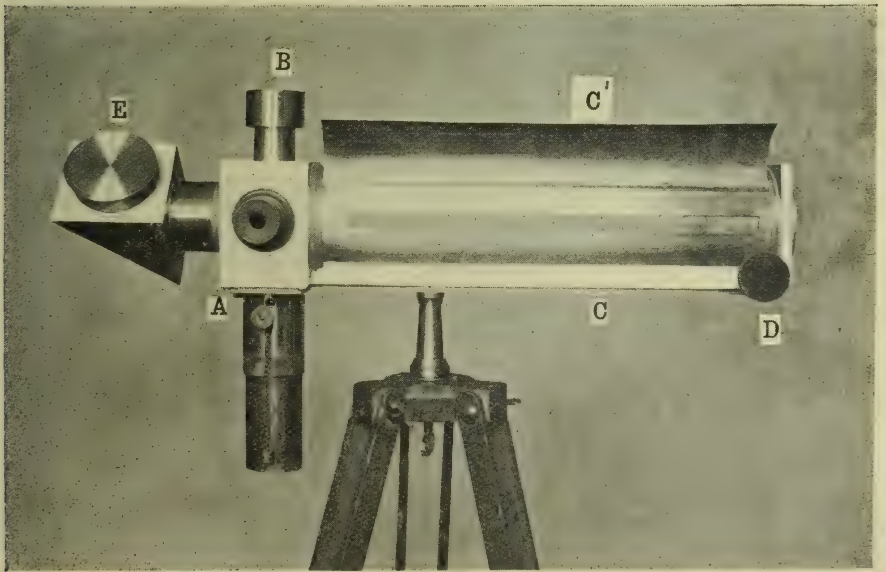


FIG. 6.—Illumination Photometer. A. Box containing Prisms and translucent screens—B. Standard Lamp—C. Tube containing adjustable mirror—C′ Cover, with transparent divided scale—D. Screen for adjusting mirrors—E. Cover for illuminated screen adapted for measurements at various angles.

structed by Mr. Trotter and others, but I have not had occasion to test their qualities personally.

It seems to me that an accuracy of 2 to 3 per cent is ample in the case of instruments of this nature.

Query 7.—For the present I must excuse myself from entering into this question, which involves other considerations remote from the purely photometrical ones dealt with above. I hope, however, to return to it on another occasion.

Dr. M. Corsepius (Cologne): The necessity for accurate comparisons of the performances of different sources has now become much more vital than it was a few years ago, owing to the introduction of the efficient tungsten lamps. In the case of arc-lamps the candle-power is commonly expressed in terms of mean hemispherical candle-power; but the candle-power of glow-lamps, on the other hand, is measured in a direction perpendicular to the vertical axis and figures giving the specific consumption in watts per candle are commonly presented on this basis. It is obvious, therefore, that the results in the two cases are not comparable. Were the mean spherical candle-power adopted as the basis of comparison the apparent efficiency of arc-lamps might often be doubled, while that of the glow-lamp would only be raised about 25 per cent; that is to say, the glow-lamps, according to the existing system of rating appear better than they really are. On the other hand, a system of reckoning the mean hemispherical candle-power of a glow-lamp equipped with a reflector, so as to rate it on the same terms as arclamps, would be unsatisfactory, because at present the great majority of glow-lamps are installed without reflectors, *e.g.*, on the ceilings of rooms, &c. As suggested in Query 4, therefore, it would be better if all these different illuminants were compared on the basis of mean spherical candle-power.

As regards Query No. 5, I should like to state that, in my opinion, the difficulty of comparing lights which differ in colour is frequently exaggerated. With an ordinary Lummer Brodhun photometer, for example, we can compare greenish and reddish lights with very fair accuracy provided the intensity of illumination of the photometer screen is sufficient.

On the other hand, it is certainly true, as I myself have found by experience, that it is very desirable to secure agreement in colour when possible, especially when a large number of tests are to be made. In the case of incandescent mantles it is therefore better not to compare the mantle direct against a Hefner standard but to utilise an electrical glowlamp screened with suitable weakly-coloured glasses. By the aid of certain combinations—for example, glasses of a blue and yellow or brownish tinge—one can obtain a light which, in the field of the photometer, seems to match that of the mantle exactly.

This system has been found to be advantageous whenever we have to make a comparison with the Hefner lamp. The calibration of the screened glow-lamps in terms of this standard should take place on a short bench, sufficient time being devoted to the comparison to get an exact result and every precaution being taken to secure as great an accuracy as possible. For the actual tests the prescribed system is very convenient since, when a large number of lamps have to be tested, the speed of the process is very materially improved and much time is saved by working with lights of the same colour.

When the globe-photometer is used a colour-match is still desirable. In this case, however, a fairly rough approximation in tint may suffice. For example, a flame arc may be compared against an under-run glow-lamp; an arc-lamp with a somewhat violet tint against a glow-lamp with a blue glass screen in front, &c. In this case, again, special care should be taken with the process of calibration (a 100 H.K. Osram lamp being a very convenient source to use).

W. J. Cady (Newark, Ohio, U.S.A.): The question of the best modern methods of obtaining the polar curves of light distribution and of measuring the mean spherical candle-power of different light sources, is of considerable interest, especially as concerns the measurement

of distribution about lamps and reflectors. It is in this question of reflector - testing that probably the greatest difficulties are met with in photometric measurement, because we have not only the colour differences which exist in the lamps themselves, and which are consequently met with in lamp measurement, but also the question of great extremes in intensity. A third important factor is that of the question of the distance from the photometer screen at which the lamp and reflector is tested.

For the distribution measurement about lamps which must be burnt in the vertical position, there are four or more types of photometers. The one type which is at present used to the greatest extent, is that of the mirror photometer in which the lamp remains stationary, and either a single mirror or a train of mirrors is rotated about the lamp, or a Matthews photometer is used with all the mirrors covered, except that in the direction in which measurement of light is desired. There are, however, several disadvantages in the use of mirrors, particularly where light units of different sizes and colours are to be measured. For instance, where a lamp and reflector are tested, the mirrors are practically calibrated for coefficient of reflection over a small portion of the mirror. This coefficient of reflection is then assumed to apply to the whole mirror when the reflector is tested. From the fact that small mirrors taken from the same large piece of mirror have shown a variation of co-efficient of reflection of 4 per cent or 5 per cent, it is easily seen that this would cause an appreciable error. If there is such a variation in the mirror, a correction cannot be applied to the reflector test, because where reflectors and globes of different sizes are used it would be necessary to determine as many correction factors as the number of globes and reflectors to be tested. Even though a perfect piece of mirror is originally obtained, this mirror would soon deteriorate, and this deterioration is not regular over the whole surface, as is shown by the fact that many mirrors become spotted.

A second disadvantage in the use of mirrors is their selective absorption. It is shown by E. F. Nichols that the coefficient of reflection of a mirror varied by 12 per cent for light from one end of the visible spectrum to the other. The following are some of the figures obtained by Mr. Nichols.

Wave Length	*Per Cent*
4300	82·7
4900	90·1
5900	91·6
6400	93·6
7500	95·0

This is sufficient to indicate that for lights of widely different colour, as the carbon, arc, and Cooper-Hewitt lights, a considerable error might be obtained in the comparison of these lights where a mirror is used.

A second possible method of distribution measurement involves the use of a Selenium cell, but this method has been but little explored. The cell could be calibrated for a given light source, but where globes which may absorb selectively are also tested, a difficulty would be presented. However, there is a considerable field for experiment in the use of this method.

A third method is a direct one, and involves the rotation of the photometer head about the lamp to be tested. This necessitates that the reader of the photometer move about with the photometer-head, which is attended with considerable personal inconvenience. Such a piece of apparatus is installed in one of the photometric laboratories in the United States, where arc lamps are tested. Two simultaneous readings are made on two photometer-heads at equal angles from the vertical, but on opposite sides, and the whole apparatus presents the appearance of a small Ferris wheel.

A fourth method, and one which makes direct readings, involves the use of the Dibdin radial photometer, in which the lamp to be tested moves in a vertical line and the comparison lamp in a horizontal line. This necessitates that the photometer screen must bisect the angle made by the two photometrical axes, but this may be done by a simple mechanical arrangement. The photometer screen need

not be a perfect diffusing surface, but it should be exactly alike on the two sides.

The question of the distance from the photometer head at which reflectors should be measured, was mentioned as an important factor in photometric measurements of this kind. The reason for this is that candle-power distribution measurements of a reflector, especially a concentrating reflector, will show entirely different results if taken at a distance of five feet or at ten feet. It is generally thought that this is due to the size of the reflector, that as the reflector is not a point source, the law of inverse squares no longer holds strictly true. This effect is due, however, more to the fact that one set of rays of light is brought to a focus at one point, and another set may be brought to a focus at another point, and if measurements are made forward or back of one of these foci different results will be obtained than those obtained by taking the measurements at the focus. As this effect does exist, photometric measurements of different light sources and different globes and reflectors should not be directly compared if these measurements have not been made at the same distance.

Mr. A. A. Wohlauer (New York): There is no doubt in my mind that the facilities presented at technical colleges and scientific institutions are not sufficient to serve even as an introduction in the fundamental principles of illuminating engineering. This is true even at the present time when the science is still in a state of development, and the possibility of setting up a very definite programme rather remote. It is necessary to impress upon the student the inefficiency and insufficiency of the production and utilization of light; the difference between light and illumination, the rules of light distribution, the design of reflectors, photometry and illuminometry, &c.

As to the fourth query, it is certainly desirable that there should be an international agreement on the subject of measuring illuminants and comparing one with another. The proper basis is, of course, that of the total quantity of light or flux. This conception should be generally adopted and popularized; whether the total or the upper and lower hemispherical flux is taken into consideration is a matter of convenience. The use of the flux as an expression of the light-giving power of a lamp is desirable on account of the fact that, in the case of line and surface sources of light, the light intensity, or even the mean spherical candle-power, has no distinct meaning whatsoever.

For similar reasons a considerable amount of investigation has yet to be carried on in order to get a sound basis for expressing the light-giving power of units where reflectors of more or less large size are employed. The so-called "apparent candle-power" only holds good for a certain distance between lamps and illuminated objects and the existing methods of calculating illumination from the experimental values of the light-giving power have to be remodelled. If this is done in a proper manner, we may hope to arrive at a better and more convenient method of doing the same kind of calculations in connexion with daylight, which is a very important subject.

However, my studies along these lines are not ripe yet for publication.

Mr. N. Macbeth (Gloucester, N.J., United States):

Query 3.—In investigating the polar curves of sources having a symmetrical light distribution in a vertical plane, I have found the protractor method of determining mean spherical or mean hemispherical candle-power more than commercially accurate; it also enables results to be obtained with comparatively little work.

This method is based on one of the well-known Rousseau diagrams, but without a planimeter. It is merely assumed that a reading, taken at the intersection of the distribution curve and a perpendicular line in the centre of each of the ten equal area zones (in the upper and lower hemisphere), represents the average intensity for each of these zones. It may be readily determined that these central zonular lines are at 18° 12′, 31° 47′, 41° 25′, 49° 28′, 56° 38′, 63° 15′, 69° 31′, 75° 31′, 81° 22′, 87° 8′. Consequently, by

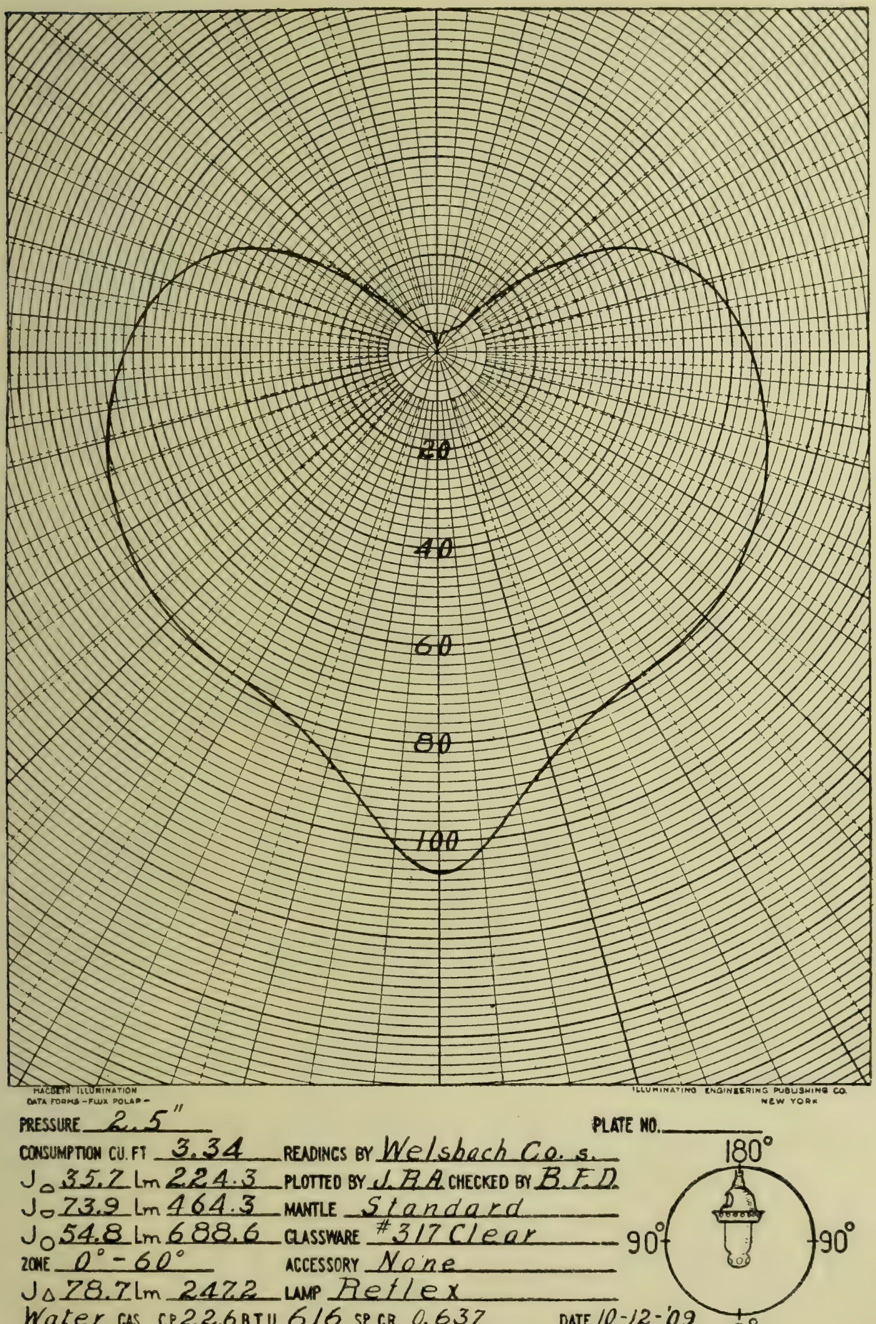

20
40
60
80
100
MACBETH ILLUMINATION DATA FORMS - FLUX POLAR -
ILLUMINATING ENGINEERING PUBLISHING CO. NEW YORK
PRESSURE 2.5"
PLATE NO.
CONSUMPTION CU. FT 3.34 READINGS BY Welsbach Co. s.
J 35.7 Lm 224.3 PLOTTED BY J.R.A. CHECKED BY B.F.D.
J 73.9 Lm 464.3 MANTLE Standard
J 54.8 Lm 688.6 GLASSWARE #317 Clear
ZONE 0° - 60° ACCESSORY None
J 78.7 Lm 247.2 LAMP Reflex
Water GAS. CP 22.6 B.T.U 616 SP. GR. 0.637 DATE 10-12-'09
180°
90°
90°
0°

Fig. 1.

making a transparent protractor with radial lines corresponding to the above angles, readings may be made on the regular polar diagram.* For the convenience of engineers, standard paper has been printed by the Illuminating Engineering Publishing Company with these irregular angular divisions as dotted radial lines, in addition to the regular 5° divisions. (See Fig. 1).

On this paper it is only necessary to read off the intensity values at each of the ten intersecting dotted lines, add them up and point off one place to the left for mean hemispherical candle-power, the mean of the two hemispheres giving the mean spherical.

We have recently adopted a "flux polar scale" for determining the effective flux in any zone of 10° or its multiple, in accordance with a method described by Codman and Rolph.† This scale is shown in Fig. 2. It is made for use with the standard 5″ by 8″ flux polar diagram paper above mentioned (Fig. 1), and, having eight scales, may be used on all curves plotted with 10, 15, 20, 30, 40, 50, 60, or 80 candle-power to ten small divisions, or to each large division; or, by assuming double or half values may be used for scales of 5, 25, 100, 120, and 160 candle-power divisions. In this way a curve may be plotted to any convenient size which gives legible results.

To use the scale, it is merely necessary to note the horizontal distance from the vertical line of the flux polar diagram to each intersection with the light-distribution curve at 5°, 15°, 25°, &c. We can thus derive the flux within any zone, or the hemispherical or total flux, in a manner that is at once simple and effective. The hemispherical or total flux values may be secured more readily by using the dotted line flux polar paper and multiplying by 2π or 4π r spectively.

Referring now to the curve plotted on Fig. 1, the mean lower hemispherical candle-power is 83·8 + 78·0 + 77·4 + 76·5 + 75·2 + 73·3 + 71·6 + 69·3 + 67·0 + 65·0 = (737·1 ÷ 10) = 73·7, and the flux is distributed within the various zones as shown below.

At	5°	read	9·8	the	flux	from	0°	to	10°	being	9 8	lumens
„	15°	„	24·7	„	„	„	0°	„	20°	„	34·5	„
„	25°	„	37·0	„	„	„	0°	„	30°	„	71·5	„
„	35°	„	48·7	„	„	„	0°	„	40°	„	120·2	„
„	45°	„	59·5	„	„	„	0°	„	50°	„	179·7	„
„	55°	„	67·5	„	„	„	0°	„	60°	„	247·2	„
„	65°	„	72·0	„	„	„	0°	„	79°	„	319·2	„
„	75°	„	73·5	„	„	„	0°	„	80°	„	392·7	„
„	85°	„	71·6	„	„	„	0°	„	90°	„	464·3	„

Query 4.—I am strongly in favour of statements of the total flux of light generated being expressed in lumens (M.S.C.P. $\times 4\pi$) when it is desired to compare various sources of light.

The terms mean spherical and hemispherical candle-power, and have been much abused and misunderstood in the past. It is also a rather difficult matter to explain clearly to those who are taking up this subject, just what these terms mean, and to avoid confusion with statements of maximum candle-power, the latter quantity having been largely used without any regard to the angle at which this maximum may be secured. We have therefore adopted and made use of the lumen as the unit of flux.

Moreover, mean hemispherical and spherical candle-power do not convey the idea of a numerical value (when we may have J⌓ = 15, J⊂⊃ = 25 and J○ = 20) nearly so effectively as when we state that the total lumens generated by a certain lamp are 251, with 94 lumens in the upper hemisphere and 157 lumens in the lower.

In reports of tests of electric lamps adequate data should always be given so that it may readily be determined whether the test conditions were regular or not. Reports appear from

* *Illuminating Engineer*, New York, March, 1908.

† *Illuminating Engineer*, New York, May, 1909.

time to time showing phenomenal results, which when investigated, prove to have been secured under conditions so unusual as to render them worthless. This is perhaps even more important in the case of gas lamps, where we should at least be informed of the pressure, consumption, kind of gas, its specific gravity, calorific value, and candle-power.

Information should also be given of the performance of the particular lamp under test, at all the usual pressures at which that lamp may be used. In this country we have from 15 tenths to 80 tenths inches of water-pressure to meet in various sections, and we have also several forms of artificial gases which differ considerably from each other.

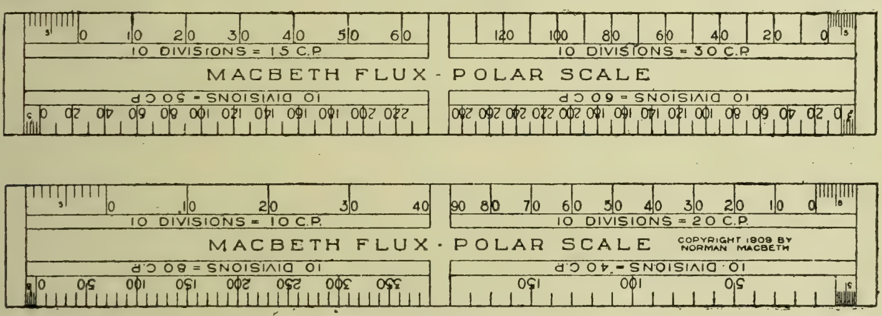


FIG. 2.

Mr. W. R. Cooper.—I should like to have some further information in regard to the experiments shown by Mr. Dow at the last meeting, indicating that a red light gave a more distinct reading than a blue light. How was the equality of the lights ensured ? The fact that there was inequality in the reading would generally be taken as an indication that the lights were not of equal intensity. Assuming that the two lights actually were of equal intensity, I would throw out the suggestion that printer's ink may perhaps, be to some extent fluorescent, and would be affected by the highly actinic light of the mercury lamp.

I feel that it is very important that the Society should take up the question of the specification of illumination ; at least, in the case of public buildings, such as schools. The subject must, of course, be divided into (1) daylight illumination, and (2) artificial illumination. There seem to be no rules in regard to daylight illumination, the architect merely putting in a window such as the building will stand irrespective of the surroundings. The illumination at any point should not be less than a certain minimum proportion of the illumination out of doors. and this proportion is one that has yet to be fixed. It is, also, not enough to specify merely this one quantity, as the question of glare should also be taken into account ; that is, the maximum as well as the minimum must be considered. This is even more important in the case of artificial illumination, which is generally specified to be "adequate," or to be given by so many candle-power per square yard. Unfortunately, good illumination depends also upon the scheme of decoration which is liable to be altered at any time, though this is not so much the case in public buildings, to which the Society should first of all turn its attention.

In conclusion, I should like to draw attention to the fact that Mr. Trotter uses the term "foot-candle" instead of "candle-foot." The term "candle-foot" has been very generally adopted, and it seems a pity that want of uniformity should be introduced unless there is some exceedingly good reasons for it.

Mr. J. S. Dow : I should like to make a few remarks on Mr. Wild's interesting table relating to the sensitiveness of different types of photometers. As explained at the last meeting, I regard the estimate of the

older physiologists that the eye cannot detect less than 1 per cent change in brightness of an illuminated surface, as conservative. We have every reason to hope that, by the adoption of more sensitive devices than those previously employed we might considerably improve on this figure.

But I must confess that some of the results given by Mr. Wild—for example, an "insensitiveness" of 0·2 per cent—seem to me better than I should have supposed could be habitually obtained. A sensitiveness of the above order means that one should be able to set the photometer with certainty to *within half a millimetre*, at the centre of a 2-metre bench, and I think that very few observers could undertake to do this with any instrument. Authorities at the Reichsanstalt and the Bureau of Standards have estimated that, under favourable conditions, results can be reproduced to within 1/5 to 1/10 of a per cent., but this refers to the mean of a set of readings.

Of course, it is always possible that greater sensitiveness might be secured by utilising some new physiological principle. For example, when flicker photometers, in which the illuminated surfaces are compared in succession instead of simultaneously, came into general use, it seemed quite conceivable that an improvement might be made by this means, though, as a matter of fact, these instruments seem to give the same order of sensitiveness to that obtainable from photometers of the ordinary variety, for lights of the same colour. Again I can understand that in Mr. Wild's special flicker photometer, in which the best sensitiveness of the grease-spot is secured by looking at both sides of the screen, and improvement might be found to exist. The same holds good for the Bechstein flicker instrument* in which a double reversal takes place, the centre and annulus of the field of view being alternately iilluminated by the two sources examined. However, I do not quite understand to what the high sensitiveness claimed by Mr. Wild's most recent device, utilising a strip of silvered mirror on plane-glass (a model of which was shown at the meeting), is due since this seems to resemble the Lumme Brodhun in principle, and I should not have supposed that the silvered mirror was any more perfect optically than the total internal reflection arrangement used in that apparatus.

As regards the use of illumination-photometers, I should like to enter a plea for greater portability and simplicity in these instruments, even if the accuracy and sensitiveness be somewhat impaired. As in the case of electrical instruments, there is room for a wide range of types intermediate between the elaborate and highly sensitive laboratory apparatus and that intended only for a rapid and approximate judgment.

In this connection, though I have not much faith (as far as present results show), in the use of "acuteness of vision" devices for exact work, it yet seems possible that they might, if properly developed, be found serviceable for approximate practical results. Another possible line of improvement is the so-called "physical" photometers, depending on some heating or chemical effect. With all the obvious difficulties of such instruments, I am not certain that they might not eventually be of service for comparative measurements. Of course, in any case the ultimate appeal must be to the eye. Selenium cells, though still very imperfect from the photometric standpoint, have been much improved. Presser* has recently described their application as a means of automatically recording fluctuations in the intensity of sources of light. Voege† has used a special thermopile arrangement for a similar object, and also for automatically tracing out polar curves of light-distribution. (This is also a line of work in which any means of reducing the tedious nature of existing operations would be very welcome).

* *Illum. Engineer*, Lond., Vol. I., June, 1908, p. 499.

* Presser, *E.T.Z.*, Feb. 24, 1910.

† W. Voege, *E.T.Z.*, Jan. 16, 1908; *Illum. Eng.*, Lond., Vol. I., 1908, p. 239.

The Direct Measurement of the Total Light Emitted from a Lamp.

Paper presented at the Meeting of the The Illuminating Engineering Society (Founded in London, 1909), on Thursday, April 14th, 1910. It is hoped that members will take full advantage of these columns for the discussion of Dr. Sumpner's suggestions.

W. E. Sumpner, D.Sc., M.I.E.E.

The quantity of light emitted by any form of lamp is measured by its spherical candle-power. The determination of this quantity is of commercial importance, and a simple method of making the test is much wanted. The best known direct test is by the use of the Ulbricht globe.

This globe no doubt yields good results in practice, but it has some defects which prevent its action from being quite accurate. It is the purpose of this paper briefly to allude to these sources of error, and in particular to discuss whether it is possible to obtain equally good or better results by using, in place of the globe, merely a rectangular box.

The accuracy of the action of the globe is dependent on at least four assumptions. In the first place, the inner surface must reflect light of all colours equally well, and the reflecting power should be high. There is no difficulty about this, but if the surface were not quite white the error due to selective colour action would be most serious, quite apart from any difficulty of colour photometry. In the next place it is assumed that there are no surfaces within the globe which absorb or reflect light. This cannot be quite true in practice. The small surface used to screen the direct rays of the lamp from the photometer window causes some error, though in most cases this error may be negligibly small. But when arc-lamps possessing globes are under test the error may be quite appreciable. Such arc-lamp globes are usually suspended near the top of the Ulbricht globe, and their action tends to prevent the upward rays of the lamp from having their proper influence on the photometric measurement. A third assumption which is well understood, is that the surface of the Ulbricht globe reflects light by diffusion only. It must be a matt surface and not shine by regularly reflected light. Such a surface is easy to procure. But a fourth assumption which I do not think has been previously discussed refers to the material of the window transmitting light to the photometer. It is assumed that this window transmits light by diffusion only, that is, it is assumed that none of the rays pass straight through it as would be the case with transparent glass. The material used for this window must be most carefully chosen, for unfortunately any translucent substance like milky glass transmits light partly by diffusion, and partly by direct transparency, and it may quite easily happen that the amount of light leaving the sphere through the photometer window is quite as much due to transparency as to diffused transmission. In such a case the effect on the photometer measurement would be serious. Part of the light received from the window would follow the law assumed in the theory of the Ulbricht globe, and would be due to the light falling on the window from all parts of the sphere. But another, and possibly equally important, portion would follow a different law, and would be due to the brightness of the part of the opposite surface of the sphere, visible from the photometer through the (transparent) window.

These properties of translucent materials I investigated together with a number of kindred matters, in a paper* read in 1892 before the Physical Society. I must refer to this paper for proof of the foregoing statement, and also for the proof (given on page 84) of a theorem, about a sphere, which I quote

* 'The Diffusion of Light,' *Phil. Mag.*, 1893.

below. Its discovery rather surprised me at the time. It forms the basis of the action of the Ulbricht globe suggested some years afterwards. The theorem was thus stated :—

"If any complete (or if any port ion of a) spherical surface be illuminated in *any* manner I_0 by the *direct* rays of a combination of light sources, the actual illumination I will exceed I_0 by a *constant amount* all over the sphere, owing to the reflective. action of the surface."

This theorem is remarkable for two things; for the ease with which it can be proved, and for its extreme generality. It does not matter how uneven the candle-power of the light is, or where it is placed. It need not be at the centre. There may, indeed, be any number of lamps placed anywhere within the sphere. It does not matter what the reflecting power of the surface is, or how the reflecting power may vary from part to part. In particular a portion of the surface may have zero reflecting power, which is equivalent to the removal of that part of the surface, and this portion may be of any shape we please. In all these cases the increase of the illumination due to the reflection is the same for every part of the surface, though of course the amount of this increase will depend on the particular circumstances of the case. The theorem results from a more elementary one which may be stated thus : *Any bright patch on the inner surface of a sphere illuminates each part of the spherical surface to the same extent.*

Now the brightness B of any part of the surface is related to its illumination, I, by a simple formula involving ρ the reflecting power of the portion of the surface considered. The formula is :—

$$\pi B = \rho I\cdot$$

each of these expressions representing the total light sent out by the surface per unit area. If we denote by the suffix zero the values of the corresponding quantities assuming no increase due to internal reflection, we have also :

$$\pi B_0 = \rho I_0$$

Now by the above theorem we know that for a sphere I exceeds I_0 by the same amount for every part of the surface. B will not exceed B_0 by a constant amount unless ρ is the same everywhere, but the excess of B above B_0 will always be proportional to ρ. In the case of the Ulbricht globe the surface is all of the same reflecting power so that ρ is constant, but it entirely depends on the value of ρ whether we can regard the surface as being equally bright everywhere or not. It is now well known that for a complete enclosure (of *any* shape) whose walls have a reflecting power ρ, the average actual illumination I is related to the average initial illumination I_0, due to the direct rays of the light sources by the formula :—

$$I = \frac{I_0}{1-\rho}$$

$$\text{or} \quad I = I_0 + \rho I$$

so that the constant increase of illumination above referred to is ρ times the mean illumination. A similar formula applies to B. Now if ρ is only 10 per cent B is essentially the same as B_0, and varies to the same extent, but if ρ is 90 per cent, B is on the whole ten times as large as B_0, and consists of a small portion B_0, which varies from one part of the surface to another, together with a portion, about nine times as large, which is constant. With the surfaces actually used in an Ulbricht globe the value of ρ is probably about 80 per cent, which means that the constant portion of B is 80 per cent of the average value of B, the rest is B_0 due to the direct action of the lamp's rays, and varies with the candle-power in the corresponding direction. With such a high value of ρ the error of the measurement yielded by the globe is probably not serious. But there would be a great error if ρ were small, and the photometer-window partially transparent. B would then be simply B_0 due to the direct rays of the light, and part of the illumination at the photometer would depend on the mode of distribution of B_0 as well as on its average value. I tried experimentally some years ago to arrange a surface of white paper in reference to an arc-lamp and a photometer, and so to shape the paper that the light reflected by it into the photometer would be a measure of the mean candle-power of the arc. This is possible,

because the shape of paper required is independent of the law of distribution of the light from the arc. But, though possible, this method proved inconvenient, and is not to be recommended. All I need say about it here is that the surface required must intercept rays inclined at all angles to the axis of the lamp. This is not true of the patch of reflecting surface used with the Ulbricht globe, for that part of the light which is transmitted to the photometer straight through the photometer-window when this is partially transparent. This globe can only give good results if ρ is large, and if the photometer-window is perfectly diffusive.

Since the Ulbricht Globe does not act with mathematical accuracy, I have considered the simpler case of a rectangular box surrounding the lamp and lined with a good white reflecting surface such as white paper, or white enamelled iron. Investigation shows that there is not any simple accurate formula connecting I with I_0 in the case of a rectangular box, as there is in the case of a sphere. But if the reflecting power of the surface is high the brightness will tend to become uniform all over the surface, and I find that *whatever the shape* of the surface is we can assume as a *first* approximation that the brightness of the surface is constant we have as a *second* approximation :—

$$I=I_0+\rho I_m \text{ and } B=B_0+\rho B_m$$

or for *every portion* of the surface I exceeds I_0 by a constant amount equal to ρ times the average illumination, the same as for a sphere. (This follows from equations 1 and 4 of the paper already referred to.) Now this second approximation must be very close indeed to the truth in the case of a nearly cubical enclosure with highly reflecting surfaces, for it is a matter of common experience that the white surfaces of walls or ceiling in ordinary rooms, so far as the eye can judge—and the eye is the only possible judge—are of the same brightness everywhere, however the lights may be arranged—except in so far as shadows on the walls or ceiling may be cast by objects in the room or by projections from the ceiling, &c. That is to say the variation of I is mainly due to I_0. Moreover, the equation is certainly true in the average, for as already stated the averages of I and I_0 must differ by ρI_m.

Now suppose the light to be tested is placed at the centre of a cubical wooden box whose inner surfaces are white and have a reflecting power of about 80 per cent. Let the length of each side be one yard, and let the box rest on some horizontal surface. Suppose on one of the vertical sides a hole is cut of dimensions 2 in. by 1 in., and that into this hole is fitted one end of a rectangular wooden tube 8 in. long, the other end being closed by one of a pair of blocks constituting a Joly photometer. The tube is assumed to be horizontal, and to be at right angles to the surface of the box. For the present we assume that the tube is open at the end fitted to the box, and not closed by a glass window as in the case of the Ulbricht Globe. The illumination falling on the inner Joly block can be balanced by that due to a comparison lamp of K candle-power placed at a distance D feet from the outer block along the line of the tube. When the balance is obtained by adjusting D we shall have :—

$$\frac{K}{D^2}=B\phi$$

Where B is the mean brightness of the surface of the cube to which the tube is exposed, and ϕ is the solid angle subtended by an area of 2 square inches at a distance of 8 in., *i.e.* $\phi=2/64$. It will be readily seen that the dimensions of the patch, on the opposite face of the cube, effective in illuminating the inner Joly block at its centre will be $10\frac{1}{2}$ in. by $5\frac{1}{4}$ in., and its area about 55 square inches. A short calculation will show that the above dimensions are suitable. For suppose the light within the cube is that of an arc-lamp whose mean spherical candle-power is 300. The light in lumens given out by the arc will be 4π times 300, or 3770 lumens. Owing to the internal reflection this will be increased in the ratio $1-\rho$ to 1 where ρ is the reflecting power 0.8 ; or the total light falling on the sides of the cube will be $5\times 3770=18{,}850$ lumens.

The area of the sides is 6 square yards, or 54 square feet, so that the average illumination I_m in lumens per square foot (or in candle-feet) will be 349 candle-feet. The mean brightness B_m is obtained from this by multiplying by ρ and dividing by π, or the mean value of B is 89 (in candle-power per square foot in the direction normal to the bright surface). Since ϕ as just shown is 1/32 it follows from the above equation that the illumination at the surface of the inner Joly block is 2.78 candle-feet and will correspond with quite a convenient balancing distance D if the comparison lamp K has the candle-power of an ordinary glow-lamp.

To calibrate the apparatus it will be necessary to put a light of known mean spherical candle-power within the cube, as in the case of the Ulbricht globe. The mean candle-power of any light used with the cube will then be inversely proportional to the square of the balancing distance D. The only assumption made is that the brightness of the patch of surface used by the photometer is always proportional to the mean candle-power of the light within the cube. As already stated this assumption is accurate enough provided the reflecting power ρ is sufficiently high. There still remains the question of the best position for the photometer tube. It should be so placed that it does not point to any part of the arc-lamp. This is easily arranged because the area of the patch of surface used is small, less than half a square foot in a side having an area of 9 square feet. The part of the surface chosen should not be that where the rays from the arc are strongest, or where they are weakest. We have :—

$$B = B_o + \rho B_m$$

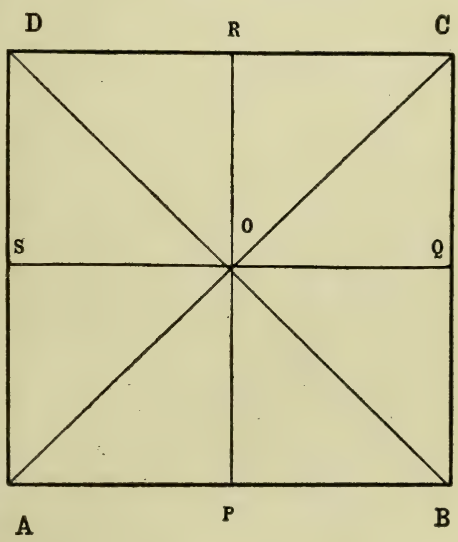
where B_o is always small compared with the total. All we want for *perfect* accuracy is to have the value of B_o/B_m the same for the patch of surface chosen, whether we test a light of uneven candle-power like an arc-lamp, or calibrate the sphere by a light of fairly uniform candle-power such as a Fleming standard glow-lamp. This end is essentially secured if we choose a portion of the surface the direct illumination of which due to an arc-lamp is about the average value due to that lamp. For arc-lamp testing the photometer tube is probably best placed on the middle horizontal line of one of the vertical faces of the box and a few inches in from one of the vertical edges.

As regards the reflecting surface of the wooden box this can be simply secured by the use of whitewash or white paper, presenting a matt diffusing surface such as is assumed in the foregoing argument. But a certain amount of regular reflection would not be any disadvantage, so that the surfaces might be of white paint or white enamelled iron. It is easy to see that the regularly reflected rays will, in the case of a rectangular box, be successively reflected at different parts of the surface, and will tend to produce the desired uniform illumination. The aperture of the illuminated enclosure can be closed by a diffusing translucent surface suitably screened from direct rays, just as in the case of the Ulbricht globe. Whether the extra complication would result in increased accuracy can only be determined by thorough testing.

There is an entirely different way of using a rectangular box for the present purpose. The theory of this method depends simply on the principle of symmetry. There are few if any commercial forms of lamp the light from which is not distributed symmetrically about an axis. Suppose the rectangular box is resting with two of its surfaces horizontal, and that the light is placed at the centre of the box with its axis vertical. It is then obvious that there are four vertical planes through the axis, each of which divides the surface of the box into two halves, and that on each of these halves the total light received is the same. If A B C D is a horizontal section of the box, and O represents the axis, the four planes in question are represented by the two diagonals and by the two central lines parallel to the sides. The light received by the portion of the surface consisting of the vertical strip A P, and the two horizontal triangles

A O P will always be a fixed fraction of the total light emitted by the lamp, and in the case of a box of square section this fraction will be 1/8 $(1-\rho)$ or 5/8 if ρ is 80 per cent. Now suppose the box is formed of wood, and that its internal surfaces are well white-washed. Suppose the part of the box represented by AOP is cut out, and that in its place is fixed a framework supporting three surfaces replacing the missing portions of the box. Let these surfaces consist of a substance transmitting and diffusing light such as opal glass or engineers tracing cloth. The light received by these new surfaces will still be a fixed fraction of the total light emitted by the lamp, and this will also be true of the amount of light diffused outwards. All that remains to do is to arrange some suitable way of illuminating a photometer by this outwardly diffused light. This object can be attained by the use of two good mirrors, one touching the top and the other the bottom of the box along an edge parallel to SO. Each mirror should be inclined 45 degrees to the surface of the box so as to reflect the light from each triangular area AOP along the line OP. The photometer should be placed along the line OP produced, and from its position the appearance will be that of three flat bright surfaces each perpendicular to the line of the photometer. If the box is a yard cube the size of these surfaces will be considerable, and the photometer distances will have to be large for accuracy. This will be no novelty in arc-lamp testing since the intensity of the light necessitates large photometer distances. For glow-lamp testing the dimensions of the cube can be made much smaller as well as those of the rest of the apparatus.

A little consideration will show that the enclosing box need not be shaped like a cube as indicated in the above figure. Thus, O might be the apex of a pyramid of which A B C D is the rectangular base, this pyramid standing on a similar but inverted pyramid with its apex at O′ vertically under O. If the light to be tested is placed within these surfaces, with its axis along OO′, it follows from symmetry that the two triangular areas AOP and AO′P will together receive one-eighth part of the light. These surfaces will be equally inclined to any line drawn from the centre through a point on the edge AB. If the photometer be placed along any such line, if the areas AOP, AO′P consist of translucent diffusing material, and if the other areas have an inner surface of high reflecting power, it follows from what has been previously said that the photometer will measure the total output of the lamp. No mirrors will be needed as in the former case, because all parts of the surface are equally inclined to the photometer line. It will also be apparent that instead of two pyramids we might use two circular cones in the same way. A B C D would then be a circle instead of a square, and for the translucent part of the surface we could choose the portion between any two planes through the axis. This latter arrangement seems the simplest of all.



In conclusion, a word or two about units. It will be a pity if the Illuminating Engineering Society help to perpetuate the use of such a cumbrous expression as mean spherical candle-power. This quantity no doubt represents the output of light from the source, but its value can only be obtained by

first of all measuring the output itself, and it is of no use except as a measure of this output. In connexion with electrical theory Oliver Heaviside has declaimed at the irrationality of estimating the output of a source by the flux it produces at a distance. It is still more irrational when the source, as in the case of light, is of such a nature that we have to imagine an artificial mathematical concept styled a "Mean Spherical" flux existing no one knows where. In the case of electricity the rationalizing of the units is now difficult if not impossible. The international units are already fixed. In the case of light this is not yet the case, in spite of all the congresses whose deliberations have left the subject in its present unsatisfactory state. It is to be hoped in the case of light that "rational" units will in the end be adopted, and that the unit of light will refer to the total output of the source, and not to its candle-power in any real or imaginary direction.

The difficulties connected with the subject may possibly make it necessary to retain, as a concrete standard of light, one having a fixed candle-power in some specified direction, but it is not necessary to continue the use of the phrase mean spherical candle-power. In practice the makers of both glow-lamps and arc-lamps consistently specify light sources in terms of their maximum candle-power. From this the total light emitted can be obtained by multiplying by some factor, and it is this factor which is wanted rather than the mean spherical candle-power. For glow-lamps the maximum candle-power is at right angles to the filament, the mean candle-power is obtained from this maximum by multiplying by a number which, as Prof. Fleming showed some years ago, is always close to the theoretical value $\pi/4$. The total light in lumens is got from this by multiplying by 4π, so that, in the case of glow-lamps, the light in lumens is theoretically π^2 times, or approximately ten times, the maximum candle-power. In the case of arc-lamps the light in lumens is roughly four times the maximum candle-power. It seems desirable to discard the expression mean spherical candle-power and to specify lights (1) by the commercial measure, *i.e.*, the maximum candle-power, and (2) by the "lumen-factor" which when multiplied by the above value gives the output of the light in lumens.

[Some communications from Dr. L. Bloch, Prof. K. Ulbricht, and others, commenting on the above paper, will be published in our next number.]

Publications Received.*

The Report of the National Physical Laboratory for 1909. The report contains evidence of further progress. In the department of photometry attention has been concentrated on the preparation of electric sub-standards of 1·1 and 1·5 watts per candle. It is also contemplated that a set of electric glow-lamps burning at 4·5 watts per candle so as to match the colour of the pentane flame, will be prepared. Experiments are also to be carried out on the behaviour of the Pentane 10-candle-power standard in hot climates.

Unsere Beleuchtung in Vergangenheit und Gegenwart by Karl H. Kuhn (Hermann Hillger Verlag, Berlin-Leipsic, 1 Mk.).

The Gas Solicitor's Handbook and *Engineering Data of the Welsbach System of Illumination*, compiled by N. MacBeth and issued by the Welsbach Co., N.J.

The Engineering Diary (Editorial and Publishing Offices, 422, Mansion House Chambers, E.C.).

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* To some of these publications we hope to refer in greater detail shortly.

The Distribution of Energy in the Spectra of Commercial Illuminants.

By W. W. Coblentz.

The following is the conclusion of the paper kindly presented by Dr. W. Coblentz, of the Bureau of Standards, Washington, U.S.A., as a communication for discussion at the hands of The Illuminating Engineering Society. The paper is an exceptionally exhaustive one, and we shall be glad to receive any communicated remarks on the subject, which we will subsequently submit to Dr. Coblentz for final comment.—Ed.)

(*Concluded from p. 261.*)

Vacuum-Tube Spectra.

The spectral energy curves of the radiation from the vacuum tube are of interest in connection with the Moore tube. It is well known that but little heat is developed in vacuum tubes, but as will be noticed by the appended illustrations, there is sufficient infra-red radiation to lower the luminous efficiency. For, as was noticed in the beginning, all our present systems of light production generate a large amount of infra-red radiation which is useless in illumination. Most of the gases in vacuum tubes have spectra not unlike the metal arcs in that they have strong emission lines just within the infra-red at ·8 to 1·2 μ. The energy put in must come out in some way, and in the carbon dioxide (or carbon monoxide) spectrum, Fig. 12, the infra-red radiation is confined almost entirely in the large emission band at 4·75 μ.

The two curves represent different gas pressures. The emissive properties of this band was found to behave differently from the usual spectral lines in vacuum tube radiation[1]. Its emissivity was found to be proportional to the pressure (thickness of radiating layer and had the characteristics of a pure thermal radiation. On the other hand, in the inert gases such as nitrogen, Fig. 13 (and helium), the emission

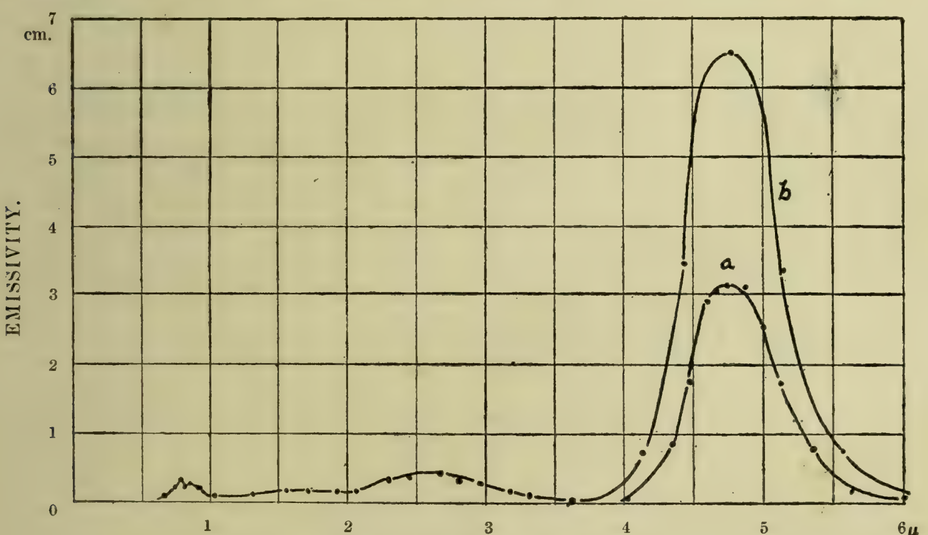


Fig. 12.—Carbon Dioxide.

[1] Coblentz, Publication 35, Carnegie Inst. of Wash., 1905.

lines are sharp, and have their maximum intensity in the region of 1 μ. The intensity of these emission lines are a maximum for a definite gas pressure, above which there is a decrease in intensity. In Fig. 13 curve *b* gives the energy spectrum of impure nitrogen, containing carbon dioxide. Curve *a* shows the same after removing the carbon dioxide. The characteristic orange-red nitrogen band is visible at ·66 μ. As in the preceding illuminants, a large amount of infra-red radiation is produced which reduces the luminous efficiency. In the present case the luminous efficiency is a maximum at a certain gas pressure. The location of the maximum infra-red emissions in these two gases is of interest, since both curves include nearly the same quantity of useless energy.

The question of the temperature of the residual air particles in the vacuum tubes during the electrical discharge, has occupied the attention of numerous investigators. The mean temperature as observed with a thermo couple is about 50° C. The theoretical temperature is 6,000° C. for the cathode glow. The position of the most intense emission lines at ·9 to 1·0 μ (*c.f.* oxides for shift of maximum intensity of bands with temperature) would indicate a temperature of 3,500° C. to 4,000° C. A promising temperature scale based upon the shift of the CO_2 band with rise in temperature may be applied. It has just been noticed that the CO_2 band shifts towards the longer wave-lengths with rise in temperature being at 4·36 μ in the Hefner lamp, at 4·4 μ in the Bunsen flame, at 4·52 μ in the carbon arc, and at 4·75 μ in the vacuum tube radiation. The temperature of these flames is now fairly well known. Extrapolating from these known temperatures to the one corresponding to the vacuum tube band at 4·75 μ we obtain 6,000° C. to 6,500° C. as the temperature of the gas in the vacuum tube.

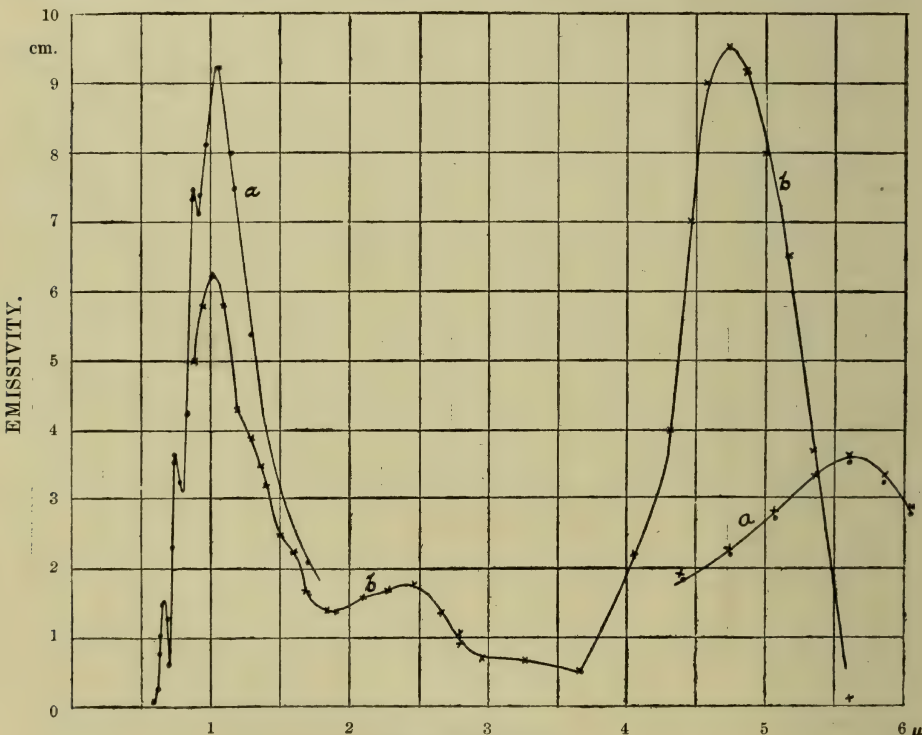


FIG. 13.—Nitrogen.

The spark spectra of metals differ from the arc spectra in that the intensest emission lines occur in the ultra-

violet while no infra-red lines have yet been observed. We have, therefore, a remarkable transference of the maximum energy partition from the deep infra-red in low temperature thermal radiation, down to a maximum emission just within the infra-red in arc and vacuum tube radiation; and finally a complete shift into the ultra-violet in the electrical (high potential spark) excitation.

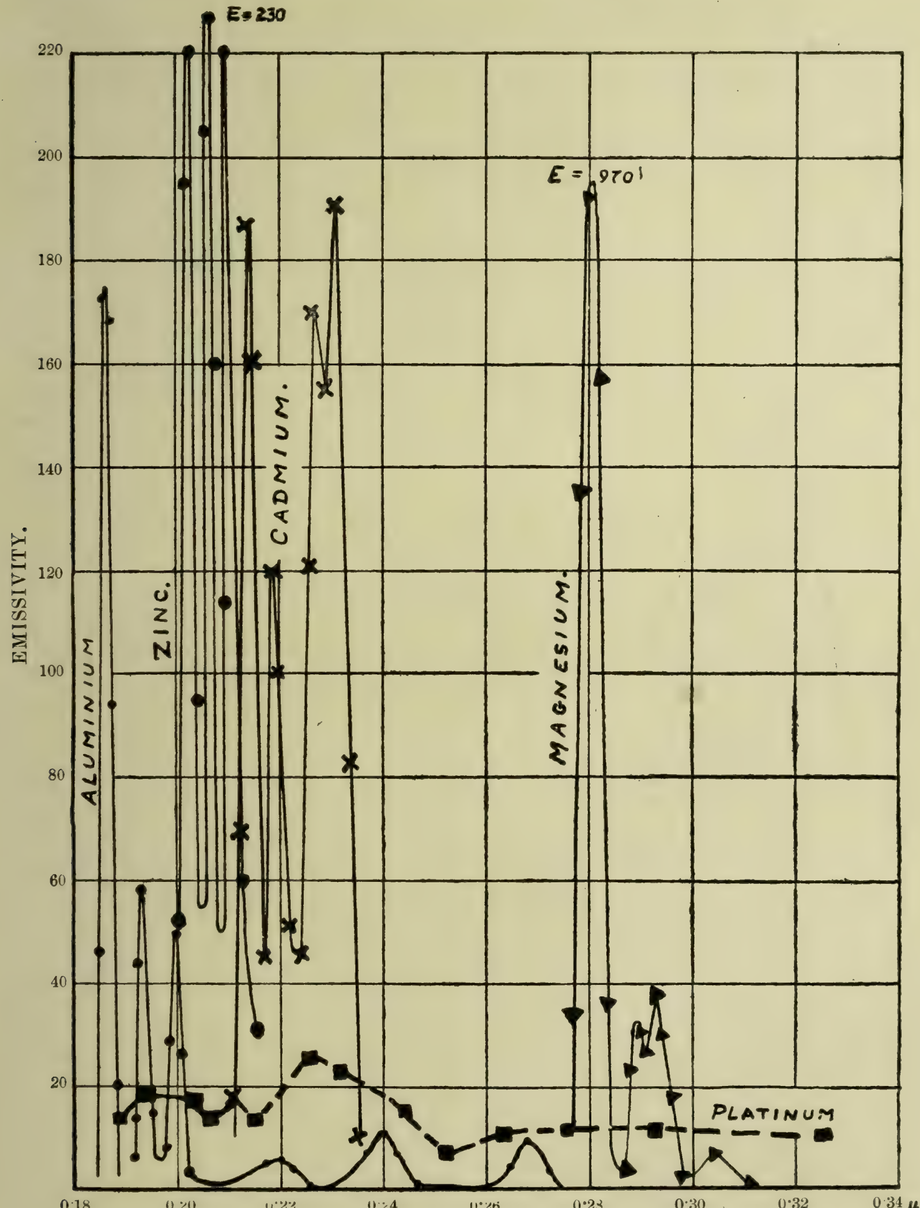


FIG. 14.—Spark Spectra of Metals (after Pflüger).

It has, of course, been well known that the spark between metallic electrodes gives strong emission lines in the ultra-violet, as shown by the photographic plate; but since the plate is not

equally sensitive for all wave lengths, no estimation of the relative intensities was possible.

The investigations of Pflüger[2] have therefore supplied a long-felt need. He examined the spark emission spectra of numerous metals, using a thermopile and a short focus, quartz-fluorite spectrometer. The intensity of some of these lines is indeed very remarkable. Perhaps this is true because we are so accustomed to thinking of the ultraviolet end of the spectrum being weak in radiation. But in spark (and arc) spectra conditions are different from the ordinary. When we stop to consider that the energy input is from a hundred to a thousand watts, and that this energy must come out again in

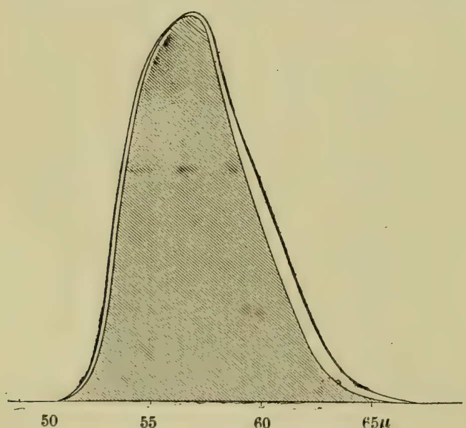


FIG. 15.
Spectral Energy of Firefly (Ives & Coblentz).

some manner, at least a great part of it as radiant energy of which but little is in the visible and in the infra-red, then it is not so surprising to find it in the ultra-violet, which is the only remaining region of the spectrum—except that of electrical waves.

In Fig. 14 are plotted some of the strongest emission lines of aluminium, zinc, cadmium magnesium, and zinc, using the data published by Pflüger. The contrast of this with the spectral energy curves of the metals given in Figs. 4 and 16 is indeed surprising, for in neither case have we produced very much energy which affects the eye; and the economic production of

[2] Pflüger. Ann. der Phys. (4) 13, p. 890, 1904.

frequencies affecting the eye is the goal aimed at by all those interested in the problem of illumination.

We have thus reviewed radiators which emit light with the accompaniment of a great deal of heat energy (low luminous efficiency) to radiators having little heat radiation and consequently high luminous efficiency.

Illumination by fluorescent excitation has not yet been developed, and before this or similar methods have arrived we shall probably know more about the methods employed by the firefly whose spectral energy curve is given in Fig. 15 (Ives and Coblentz; *Bull. Bureau of Standards*, vol. vi. No. 2, 1909). The shaded area represents the quantity of useful radiation which amounts to almost 97 per cent.

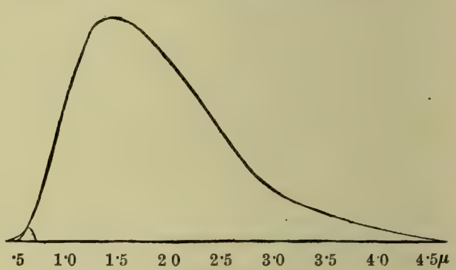


FIG. 16.
Luminous efficiency of Flashed Carbon.

THE MEASUREMENT OF LUMINOUS EFFICIENCY.

In discussing the foregoing spectral energy curves the luminous efficiency was estimated by comparing the spectral energy affecting the eye with the total energy radiated. In theory this would seem to be a very satisfactory procedure; but the practical application is far from satisfactory, and can lead to only approximate results. The number of papers on this subject is too numerous to mention. Some experimenters have observed the spectral energy curves and have taken the ratio of the integral part of the curve lying in the "visible" part of the spectrum to the integral of the whole spectral energy curve (in practice observations extend to only 10 or 12 μ) and have called this the luminous efficiency of the light source. Others have multiplied the spectral energy

curve in the visible spectrum by the sensibility of the eye. This gives the shaded areas in Figs. 15 and 16 (data from Ives and Coblentz).* The latter gives the spectral energy distribution of a 4 w.p.m.s.c. treated carbon filament in which the luminous efficiency is only about 0·4 per cent of the energy which passes through the glass bulb. This value would be still lower provided a correction were applied for the absorption of the glass walls, which amount to 10 or 15 per cent., depending upon the thickness of the glass. This is the most satisfactory of all the radiation methods that have been applied. The recent work by Féry, Lux, Voege, and others, is of interest, but is far less trustworthy. They measured the radiation which was transmitted through solution having a transmission band corresponding closely with the sensibility curve of the eye. They measured also the total radiation transmitted by the glass bulb. These ratios cannot be very accurate, since no account is taken of the variable absorption of the glass bulb. Moreover, it is not fair to compare such observations on glow lamps with similar observations on candle flames in which the glass chimney has been removed, because as was shown in Fig. 9, a very considerable amount of energy is radiated in the CO_2 band at $4{\cdot}4\,\mu$. Such measurements may be very misleading as will be noticed in the arc and spark spectra of metals, *e.g.*, copper arc in which infra-red radiation is extremely small. On the basis of the ratio of the visible to total radiation the luminous efficiency would be very high, because no account is taken of the other energy losses.

The suggestion that the consumer pays for his lighting on the basis of the total radiant energy output does seem practical, because of the impossibility of accurately accounting for all the energy losses, and it appears quite certain that the consumer will continue a while longer to pay for what he obtains in energy input, which is not difficult to determine.

Washington, D.C.,
Nov. 10, 1909.

* *Bull. Bureau of Standards*, vol. vi. No. 2, 1909.

Town Planning.

A COMBINED meeting of the Junior Institution of Engineers and of the Architectural Association Debating Society recently took place at the rooms of the Architectural Association, Tufton Street, Westminster, for the consideration of the subject of 'Town Planning,' the architect's point of view being represented in a paper by Mr. Stanley Hamp, and the engineer's in one by Mr. Frank R. Durham. The importance of comprehensive and orderly planning, and the necessity of provision for development was urged by Mr. Hamp, in illustration of which reference was made to Paris, Germany, and America. The limitation of town areas, open spaces, and grouping of buildings were dealt with, and the difficulties due to various circumstances in regard to the character and height of buildings to be erected were touched upon, the value of forecourts in any scheme, and the position of public buildings, traffic problems, &c., were discussed. Mr. Durham showed how essential it was that the architect and engineer should co-operate, and made reference to the pioneer and later work in Germany, Austria, &c., carried out by Mr. W. Lindley, including the rebuilding of the city of Hamburg. The æsthetic, hygienic, social, and economical principles involved in the question were reviewed, and the author showed that the sewerage system was a determining factor in designing main arteries, the Housing and Town Planning Act of course receiving notice.

A discussion followed the reading of the papers, and a vote of thanks to the authors brought the proceedings to a close.

The Legal Aspects of Shop Window Displays.

A MEETING was held at the Holborn Restaurant, London, on Monday, April 4th, for the purpose of considering the legal position of traders whose windows caused crowds to collect on the pavement. Mr. Carl Hentschel presided.

Mr. Toye Vise, a member of the committee, explained that the meeting really had its origin in the attitude taken by the police authorities regarding a recent display at Swan & Edgar's. The effect had been to cause a crowd to collect. Under present conditions any attempt of shopkeepers to strive after novelties and effective display in their windows was penalized, because they were liable to prosecution in the event of this leading to a crowd.

The chairman narrated the circumstances, contending that the law as it stood seemed to be unequal. Theatres were allowed to create crowds which were kept in control by the police, and newspapers were allowed to exhibit election figures which had the same result of causing people to assemble. But a shop-keeper or restaurant-keeper was debarred from taking steps to make his window attractive, though traders were quite willing to pay for police supervision if it were needed.

Mr. Conly, on behalf of the legal adviser to the committee, suggested that a deputation should be appointed to wait upon the Commissioners of the Metropolitan and City Police, regarding the matter.

The following resolution was then proposed by Mr. North White, seconded by Mr. H. Simonis, and adopted :—

> That this meeting expresses strong dissatisfaction with the state of the law or practice of the police, the effect of which is to penalize the trader who shows enterprise in taking legitimate advantage of the opportunity for effective advertisement of his goods in making his shop windows especially attractive, as exemplified by recent prosecutions of traders in London and elsewhere.

Subsequently the following resolution was put by Mr. J. P. Hunt and seconded by Mr. L. Gaster :—

> That a deputation be appointed from this meeting to wait upon the Commissioners of the Metropolitan and City Police respectively, with a view to securing that authority shall be given for police assistance to be afforded to traders when necessary in the regulation of crowds assembling outside business premises, and to obtaining guidance as to within what limits or under what conditions window displays may be made especially attractive.

Mr. L. Gaster said he spoke as one interested in shop lighting, which, he pointed out, was a powerful means of calling attention to a shop window, and thus causing a crowd to collect. Nowadays the lighting arrangements of a window were very important.

He therefore thought that it was necessary to make a distinction between light wisely used and light which constituted a nuisance. A shop-keeper acted quite naturally and legitimately in using his lights to show off his wares, but powerful and brilliant unshaded lamps, hung low down, acted as a menace to traffic on account of their dazzling effect. In such cases he thought the police were acting fairly in restricting the abuse of light.

On the other hand it did seem to him just that the trader who merely wished to make his window attractive should receive consideration. From a wide experience of European countries he could assure those present that the police in this country were exceptionally forbearing and reasonable. He felt sure, therefore, that they would be willing to consider the claims of shopmen in this respect, and hoped that the deputation might be beneficial in making the position clearer.

Factory Lighting.

On Saturday, April 2nd, a paper on 'Illuminating Engineering as Applied to Factory Lighting,' was delivered by Mr. L. Gaster before the London Association of Foreman Engineers and Draughtsmen, the President, Mr. J. Harrington, being in the chair.

In opening his remarks Mr. Gaster explained that factory lighting was a big question, and that he only desired to make a few suggestions and to emphasize the importance of the subject. Time was not yet ripe for definite recommendations. However, from a practical standpoint there could be no doubt that it was very essential that the method of illumination should be very carefully chosen, because the cost of good lighting was usually small in comparison with the improvements in quality and output of work that would result. It had been found that a majority of mistakes and accidents in factories took place after 4 P.M., when the daylight illumination has begun to fail and to be replaced by artificial light. Illumination was obviously specially important in cases in which accurate work was necessary. In this connexion Mr. Gaster referred to the story of Sir Joseph Whitworth who related how, in his boyhood days, the test for accuracy in fitting the piston of a steam engine to its cylinder was to drop a shilling piece in and rattle it round; if the coin did not fall down between the piston in the cylinder the job was considered a "fit." In those days illumination was very dim, and the marvellous accuracy of to-day might have been impossible for this reason alone.

Bad lighting, again, led to the accumulation of dirt, and meant that machinery was badly looked after and neglected. In addition, workmen in gloomy, badly lighted surroundings were naturally inclined to suffer in health; the report of the Chief Inspector of Factories for the last year had contained special reference to this subject.

Mr. Gaster then inquired what constituted good illumination in factories? He alluded to the need for sufficient light, and the importance of avoiding anything in the nature of glare. A common source of glare was light reflected from shiny surfaces into the eyes of the workmen. Flickering, shaky lights were also very trying. For this reason, he pointed out, it was often inadvisable to use a few powerful lights at intervals in shops with a great deal of belting and revolving machinery, as these might give rise to irritating moving shadows. Local lighting with small units helped to mitigate this difficulty.

Mr. Gaster gave a summary of some of the relative merits of inverted lighting, powerful lights hung high up at intervals, and local shaded lights. He then proceeded to show a series of lantern slides, showing factory lighting by "Excello" flame arcs, Keith incandescent gas lighting, oil lamps of the Kitson type, and other illuminants. Several slides also showed the use of the Imperial acetylene outfits for lighting in emergencies, and in places where gas and electricity were not available. Mr. Gaster added that in his opinion it was useless to try to lay down figures of cost which could be utilized for all purposes. In reality each case had to be considered on its merits.

When the discussion had been opened Mr. G. Watkinson gave some of his experiences in connexion with lighting by means of high power units at intervals. This he considered less satisfactory than smaller local units. For example, the delicate operations in connexion with the manufacture of steel nibs were best done by the light of a candle provided with a proper screen. Again the use of powerful lights was often inefficient because it

meant that the whole room had to be lighted for the benefit of a single person. The speaker added that he was not quite certain that accidents occurred after 4 o'clock as stated. In his experience they had been found to occur chiefly very early in the day, before the workmen had settled down to their work.

An interesting illustration of the value of light was its effect in reducing crime. In Paris the authorities had found that whenever a street had a particularly bad reputation it could be improved by installing a few powerful lights.

Mr. G. W. Knight admitted that in considering the cost of lighting each case had to be considered on its merits.

It depended on how a particular illuminant was utilized whether one got the best out of it. He had experimented with many systems of lighting, and found he had still many difficulties to overcome. He confirmed the suggestion that accidents tended to occur after 4 o'clock, especially in the twilight.

Mr. Jenkinson said that the man who declared that gas or electric light was invariably the best was making a mistake. It was impossible to state, without knowing the exact circumstances of the case, which would answer best. The study of illumination was a very complicated one, and it was impossible for one man to do his own work, and also to know how to use light. Therefore he welcomed the suggestion of the need for an illuminating engineer.

He, in his own work, had been impressed with the value of small units, both on account of cheapness and evenness of illumination. One result of using a few big and brilliant lights was that anybody working in the room was sure sometimes to look straight at one of them and become dazzled when doing so.

In conclusion, Mr. Jenkinson referred to some experiences in a bank which illustrated how people came to expect a higher standard of illumination. In this case a man who was short sighted had asked for and obtained a special bright light over his desk. The result was that all the other clerks clamoured for the same conditions.

Mr. W. Smith, Mr. W. Bamford, and Mr. J. Thomson also spoke, the latter pointed out that in factory lighting expense was the chief item. For his part he thought that an ideal system of illumination ought to resemble daylight, and therefore he favoured the inverted system, especially in drawing offices, as it was impossible for a man to get dazzled by looking at the source under these conditions.

At the conclusion of the meeting a vote of thanks was proposed to the lecturer, and many of those present before parting, expressed their conviction that there was a great deal more worthy of study in connexion with factory lighting than they had previously supposed.

Some Examples of Factory Lighting.

The four illustrations on pages 337 and 339 are similar to some of those shown at the meeting referred to above.

Figs 1 and 2 are made from photographs kindly lent to us by Messrs. Keith & Blackman, and represent installations of the Keith high-pressure system to which reference has previously been made in this journal. The system, it will be recalled, utilises a pressure of about 54 ins., and this, in conjunction with the pre-heating arrangement, is claimed to enable an efficiency of 60 candle-power (horizontal) per cubic foot of gas consumed to be obtained; this candle-power is measured from the mantle alone without the aid of any reflector. The use of the pre-heating in this connection is interesting. Some authorities have contended that with low-pressure inverted

Fig. 1.—Illumination of Stonemason's Yard by Inverted High-Pressure Keith Incandescent Gaslights.

Fig. 2.
Illumination of Compositor's Room in Printing Works. High-Pressure Keith Inverted Incandescent Gaslights.

burners it is undesirable, and leads to a tendency to light back. When high pressure is available, however, this difficulty is not experienced in the same way, and the advantages of the method are secured.

Figs. 1 and 2 illustrate the two chief methods of illumination used in factory lighting, namely, powerful sources placed high up when it is desired to produce a good general illumination, and smaller units at intervals such as are employed when it is not necessary to flood the whole room with light and only a good local illumination is needed. The stonemason's yard in Fig. 1 naturally calls for conditions of illumination of the former kind. It might have been supposed that the amount of dust from the stone would have given trouble. It is stated, however, that the dust being of a heavy character, is not readily sucked into the burner, in the same way as that in a flour mill, for example. Even in the case of flour-mills, the difficulty is experienced less with high pressure because the velocity of gas prevents a tendency to choke up the burner and the particles of flour are carried through and driven into the mantle. Presumably under such conditions the wear and tear of the mantles would, however, be somewhat increased.

Fig. 2 shows a compositors' room equipped with local 100-candle-power inverted lights. In this case what is wanted is to produce a powerful illumination over the compositor's desk and an inverted mantle, equipped with a suitable reflector, is distinctly advantageous by throwing the light downwards.

The other two illustrations representing installations of Excello arc lamps, are reproduced by the courtesy of the Union Electric Co., Ltd., Fig. 1 shows the illumination of a large engine room by flame arc lamps placed high up. This, again, is a case in which it is presumably desired to flood the entire floor area with light. A powerful downward illumination yielded by flame arcs with inclined carbons is, therefore, advantageous, and the lamps being placed high up out of range of view, are not likely to interfere with the eyes of the workers below. The last illustrations, Fig. 4, again, refers to a compositors' room in the printing works. It will be seen that the treatment is distinctly different from that employed in Fig. 2. Inverted Excello arc lamps are here used, a strong general illumination, coupled with absence of glare being chiefly aimed at.

Some Notes on the Illumination of a Weaving Room.

By L. B. Marks.

We have received from Mr. Marks a reprint of his recent article in *The Illuminating Engineer* of New York, in which some of the chief points to be observed in factory lighting are admirably brought out. Mr. Marks describes the improved illumination of certain mills in the United States where silks, velvets, worsteds, &c., are manufactured. The proprietors were considering the illumination of a newly-built mill and contemplated adopting a system of lighting similar to that employed in the old one.

The lighting in that case was of a strictly localised character, and it was objectionable in several respects. For example, many of the reflectors were too shallow, thus exposing the eyes of operators to the unshaded filaments. In addition, too much illumination was provided in some quarters and too little in others, while the condition of the lamps, reflectors, and globes was very

FIG. 3.—Engine Room Illuminated by Excello Arc-Lamps high up.

FIG. 4.—Printing Works, Composing Room Illuminated by Excello Inverted Flame Arcs.

unsatisfactory; many of the reflectors, for example, were badly tarnished and thickly covered with dust. Eventually the owners of the mill were persuaded to adopt a modified system involving a combination of general illumination with local lights. Although the new method would consume more power, they were brought to see that the improved illumination would render the change economical in the long run.

One characteristic of the old system of drop lamps was that the illumination, even over the working surfaces of a single loom, varied enormously, being 100 times the value at one end than it was at the other—and this within a working space of only 6 ft. An interesting contrast existed between these conditions and those prevailing in daylight. In the latter case the diffusion of illumination was very good, and it was found that the minimum intensity sufficient for the work was slightly over 3 foot-candles. Now when the artificial lighting of the looms was examined it was found that at distances of more than 3 ft. from the local lights the intensity of illumination fell away to about one sixteenth of the above minimum. In addition the arrangement of local concentrated lights was such that the strong glare reflected from the bright surface of the machines was very trying.

According to the new system of lighting introduced, however, the minimum intensity of the artificial illumination on the working portion of the loom fully exceeded the minimum prescribed. In addition, the reflecting value of the white ceilings and the walls is utilised much more effectually than was the case with the old conditions.

The Eyesight of School Children.

In a recent number of *School Hygiene* some figures are given, regarding the eyesight of school children in Germany, which are taken from the most recent report on School Medical Inspection in Berlin for 1909.

In the very first issue of *The Illuminating Engineer* figures were quoted from a large number of sources showing that defects in eyesight tend to increase steadily throughout school life.* The figures of Dr. Meyer here referred to are of the same effect, the proportion of children suffering from defects being, in the highest classes, double that in the lower classes. In this connexion he says: "although a not inconsiderable percentage of children come into school with inherited defects (chiefly myopia and stigmatism), and although other factors partly account for the great increase, it is, nevertheless, quite certain that the school is itself responsible for a large proportion of the increase, as has been demonstrated some long time by repeated observations. One must ever re-insist upon the questions of lighting, overwork, writing posture, and desks."

We note that another article by Mr. Robert Jones in the same journal draws attention to the desirability of avoiding basement premises for schools. He mentions one case in which subterranean instruction in hygiene took place in a school, a portion of which lay four or five feet underground; and this, he says, "was thoughtfully reserved for the infants, and the teachers in this department had a tendency to become bleached." It was only with difficulty that a moderately pure atmosphere could be maintained. The author draws attention to the anomaly of teaching hygiene under these circumstances; in this connexion the author states that he has known the best equipped gymnasium in this country to be night after night suffocating with hot breath and gas-heated air.

* *The Illuminating Engineer*, Lond., vol. 1, 1908, p. 58.

The Lighting of the New South Kensington Museum.

By an Engineering Correspondent.

The lighting of museums and galleries intended for the display of objects to students and the general public is always a matter demanding careful consideration. Fortunately, as the work is one undertaken by either local or national governing bodies, it is one in which cost, both of installation and upkeep, is but a secondary consideration. At the same time the substitution of one or more unwieldy departments for a single authoritative organizer is not infrequently attended with very objectionable consequences.

As with the immortal page-boy in the palace, whose kicks and orders were passed down from royalty itself through ever diminishing degress of rank, and who, having none below him but the cat, must needs bear the one and execute the other, so praise and blame may at times be unjustly given, and are at all times difficult to apportion.

A scheme of lighting originally prepared by some sub-assistant-engineer, from plans which indeed may show the areas and proportions of rooms, but which give little indication of the purposes for which those rooms are to be used, may be altered by a superior with a less intimate knowledge of the requirements, may be further altered by an architect who considers the positions chosen for the lights interfere with some artistic feature of his structure, and may be further mutilated, or, on the other hand, may be accepted without question, by some official of the department for which the building is to be erected who is quite unqualified to criticise so technical a matter. Some dozen officials in divers departments having signified their approval and the Treasury having consented to the expenditure of the money, tenders can be invited and the work commenced. To depart from a scheme so approved is henceforth almost a crime. It is approved in writing: who dare alter it? Assume for a moment that in the course of carrying out the installation some possible improvement presents itself to those in charge of the work. It is no longer possible to effect this by a simple consultation between the architect, the engineer, and the future occupiers, but the matter must be put in writing and sent the whole round, for man by man to write remarks on and initial before returning it by the same round to its starting point. The delay at the best must be serious, but how much more so it may become is evident when it is remembered that the absence of any one man may hold up the matter for days or weeks, and the more responsible a man's position is the longer are his holidays and the less willing are others to touch his work during his absence. Owing to this degree of inertia in large Government Departments, it is probable that improvements are not always adopted as readily as might otherwise be the case.

Further defects which appear to be due to lack of foresight may frequently be traced to changed plans, and these again to changing personalities, especially in the case of buildings which have taken years to construct.

It is necessary to bear these points in mind in considering the illumination of the new portion of the Victoria and Albert Museum at South Kensington, which was opened by His Majesty in June of last year, 10 years after the laying of the foundation stone by Queen Victoria. It is not proposed in the present instance to discuss how far the objects are successfully displayed by day, except in so far as that may be necessary for comparison with the electric lighting.

It is to be expected that, in so

important a national collection, every care should have been taken to provide the best and most suitable lighting and to make this an example of all that is best and most up-to-date from the point of view of the illuminating engineer.

For the information of those who have had no opportunity of inspecting this building, it may be said that the galleries to be dealt with can be divided roughly into:

(1) Large Courts, usually 50 ft. wide and about the same in height, but of various lengths, which, in the daytime, are lighted from the roof.

(2) 30 ft. galleries of various lengths, from 16 to 20 ft. in height, and (with the exception of the top floor, which has a glass roof) lighted in the daytime from windows along one side only of the gallery.

There are, in addition, a circular, or rather octagonal, court, upwards of 110 ft. in diameter, covered by a glass roof some 60 ft. or more from the ground, and sundry smaller corridors and pavilions.

The most obvious method of treating such galleries electrically is to use arc-lamps of a fair size in the large courts and either incandescents or small arc-lamps in the smaller galleries: and this is the system which has been adopted. The alternative of using large inverted arc-lamps for the smaller galleries is usually considered wasteful, but this is not the experience at the neighbouring National History Museum, where the bird-gallery has been lighted in this way, not brilliantly, perhaps, but quite sufficiently and far better than by daylight, at an expenditure of current which compares very favourably with the figures given below for direct lighting at the Victoria and Albert Museum.

During the hours of daylight the objects are, as a rule, well displayed even when it is found necessary to draw sun-blinds across certain windows to protect the more perishable colours in the textile exhibits. This is, unfortunately, not always the case in buildings of such substantial construction. The object of the lighting engineer should have been to maintain as far as possible a similar illumination after nightfall without undue extravagance. Let us consider, therefore, how far this object has been attained.

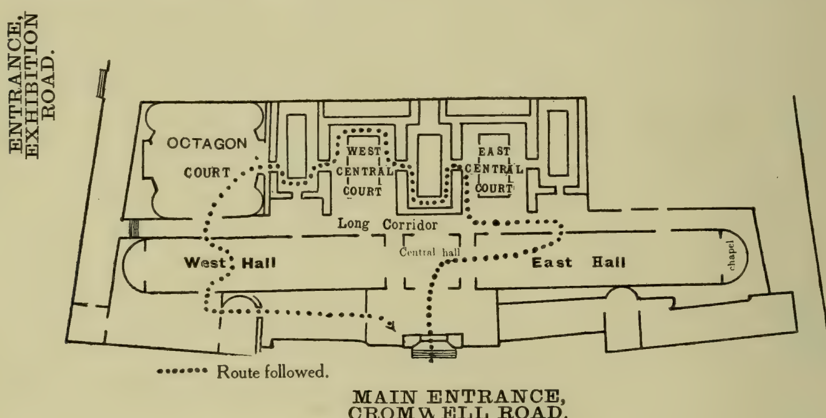


FIG. 1, showing Portion of Museum Visited.

Arriving in the Central Hall from the main entrance under the tower, the chief of the large courts, over 600 ft. from end to end, lies right and left of the visitor. The section to the right, known as the East Hall, is (if we omit the apse which is now filled by an old Italian Chapel and which has received special treatment), 230 ft. long by 50 ft. broad, and, as the artificial light is supplied by 28 arc-lamps hanging in two rows, each lamp illuminates about 410 square feet of floor space. The

lamps, in common with those used throughout the large courts, are 8-ampère enclosed ones, burning two in series on a 200-volt continuous-current circuit and hanging at about 20 ft. from the ground. The objects in this court are mainly big architectural ones, with, at present, large intervening spaces giving a general impression of emptiness, which will doubtless vanish as further objects are arranged. Moreover, the walls being distempered almost white, a great amount of light is economised by reflection which may not be the case when the final decoration of the building is undertaken. Bearing these two points in mind, it is probable that the light provided is about what may be needed at some future time, but it is indisputable that at present a wastage of current is taking place and at least a third, very possibly even a half, of the lights could be switched off as unnecessary. Taking into consideration the nature of the objects, which do not so abound in detail as to demand facilities for minute examination, the brilliant lighting is the more to be deplored, but, as pointed out, it is the users rather than the designers of the installation who should be blamed for this.

Crossing the Long Corridor into the East and West-Central Courts an even greater brilliance is encountered. Each of these courts has 16-8-amp. arc-lamps to light a floor space of 90 ft. by 70 ft. As will be observed, the area served by each lamp is but little lower than in the East Hall, being 393 sq. ft. instead of 410 per lamp, the additional glare being more due to some of the lamps hanging at 17 ft. from the floor as against 20 ft. in the other case. It must be admitted that the construction of the court with side arches and columns makes the present number and arrangement of lamps almost the only possible one and the best way out of the difficulty would appear to be the substitution of smaller lamps in the two side rows. These two courts are used principally for the display of immense carpets and tapestries in glass cases. Glass is no doubt necessary for the preservation of the fabrics, but, from an exhibition point of view, it is most undesirable. By day all light-coloured objects behind the observer, the mosaic floor and whitened walls, and by night the rows of arc lamps, are reflected with distressing distinctness in the sheet of glass so that examination of the materials is difficult both from long and short distances. The trouble by day is unavoidable, but scarcely so painful as when the arcs are switched on. There appears to be but one remedy, and that is—to light the cases internally, and it is at least questionable whether, with such large objects, this could be done satisfactorily, for, to obtain an approximately even distribution of light over so large a surface, the lights would have to be a considerable distance in front of each object, and this would necessitate the glass being too far removed for students to examine the texture closely.

On leaving the West Central Court, a court of the old museum, dimly lighted by an early type of open arc-lamp, is passed through into the Octagon Court. This court, with a floor space of about 11,000 sq. ft., is well lighted by a circle of twelve 8 amp-arcs which hang at the 40 ft. radius some 22 ft. from the floor. The floor-space per lamp is, therefore, over 900 sq. ft., and the wattage per square foot 0·87. The actual number of lamps in the circle is 24, but only alternate lamps are used: the condition, therefore, is the reverse of that in the East and West Halls, where a somewhat more bountiful provision is available, and full use is made of it—very needlessly, as has been pointed out.*

How serious a waste of public money may result from any extravagance in lighting will be realised from the fact that 280 units are consumed *hourly* during the three nights a week on which the museum is open to the public until 10 p.m., exclusive of the current for power to the lifts and fans, and to this should be added the expense of trimming.

The objects in this court are of a very varied description—metal-work,

* Since the above was written it has become customary to light 18 of the lamps.

lace, china, and other things, as here are gathered together many of the private collections lent to the museum by their owners. As a rule the objects are not large, and are arranged in cases about 6 ft. high.

The long corridor which divides the large courts from one another has a first floor corridor running over it from which there are many openings and balconies looking into the upper parts of the large courts. It might be thought that the arc lamps, hanging as they do just below the level of the eyes of those who stand at these openings, would be found to be very objectionable. The annoyance has been guarded against, however, by providing all the nearest lamps with oblique metal shades, and it is surprising how possible it is to look down into the courts without being conscious of the fact that the nearest of these lamps is there at all : the glare from the further ones is, of course, softened by distance.

Passing through the West Hall and up the steps under an Indian archway one of the side-lighted galleries is reached — the South-Western, Ground Floor Gallery (No. 56) which is devoted to wood-work exhibits. This is a gallery 106 ft. long by 30 ft. wide, and nearly 20 ft. high. The lighting arrangements are those which have been adopted as the standard throughout the incandescent lighted galleries. There are two rows of 6-light fittings (in this case 7 in each row), the lamps being 28-watt, obscured, metallic-filament, 2 in series on the 200-volt circuit. The fittings are of the chain type, having a flat ring 2 ft. 3 in. in diameter to carry the lights, and this hangs at 9 ft. from the floor. Each lamp is fitted with a 6-in. opal saucer shade—very desirable from the illuminating point of view, but, on a real-bronze fitting, questionably so from the artistic one.

This arrangement of lighting is a very pleasant and effective one, a very even distribution and ample light being obtained. In the case of the ceramic, enamel, and book galleries, which have cases not exceeding 6 ft. in height, it is all that could be desired, but in the galleries devoted to wood-work and furniture the whole arrangement has been spoilt by a rigid insistence on the standardised height of 9 ft. to the ring of the fitting. It is indisputable that in these particular galleries the whole of the fittings ought to be raised about 2 ft., for very many of the objects exhibited are wholly or partially above the lighting line, and in addition, both by day and night, the fittings themselves constantly obstruct the visitor's view. It is a matter very easily remedied by cutting out a few links of the chain, and it is surprising that those responsible have not seen to it already. The need for this is no doubt a result of alterations in the plan of arranging the exhibits already referred to, and this again is due in all probability to the passing of authority from the Board of Education to the newly-appointed Director of Art during the progress of the work. It results in a particular instance of the evil arising from the adoption of any stereotyped method of lighting particular galleries in a particular way, irrespective of the objects which will eventually be placed in them.

It cannot too constantly be borne in mind that, broadly speaking, those objects whose characteristics are those of form and contour depend for their effect on the *position* of the light : the ones whose beauties are those of colour must be considered from the point of *quality* of the rays of light : and those objects whose principal interest consists in details of structure and composition must be provided with an abundant *quantity* of illumination.

All the other galleries which are similarly lighted by 6-light fittings take practically the same number of watts per square foot of floor space as in this case, that is 0·74 watts, and, if we reckon the 28-watt lamps as being of 25 c.-p., there is one candle for each 1½ ft. of flooring, or very nearly our old friend " one 16 c.-p. lamp for every 50 sq. ft."

In the case of the ceramic galleries, all available wall-space has been covered by glass cases, 8 ft. high, and projecting about 14 ins. Additional lighting has been provided, very wisely,

for these by lamps in enamelled "trough" reflectors, shining through the glass tops. One 28-watt, clear, metallic-filament lamp is used for 3 ft. of case, and, as they are kept close to the front edge, they are screened from the eyes by the metal cornice unless the face is brought quite close to the glass front of the wall-case. These cases are fitted with a number of glass shelves, and, as experience at the British Museum had shown that when using clear glass the shadows of objects on the upper shelves were thrown on lower exhibits and that ground glass for all shelves too seriously obstructed the light towards the bottom of the case, the top shelf only has been made of ground glass and the remainder of clear, with very satisfactory results.

To those unacquainted with the conditions of museum lighting, it may seem that some system of tubular or other lighting *inside* the cases would have been preferable. The objection to this method is that the electricians would have no access to the lamps, as there is a strictly enforced regulation, necessitated by the great value of many of the exhibits, that cases may only be unlocked in the presence of one of the higher officials of the museum. The wisdom of insisting on this precaution in the case of objects which are of little intrinsic value and of considerable bulk will strike the general public as questionable and as being a regrettable instance of "red-tape."

The architectural features of the top-floor galleries, which, as has been mentioned, are lighted by a glass roof instead of by windows along the side, have necessitated the fittings being hung rather nearer the walls than is desirable for the best distribution of light, and this, added to the lack of the reflection which is obtained from the white ceilings on the lower floors, make these galleries scarcely so well lighted as the latter although the candle-power per area is identical. This effect is also due in part to contrast with the pavilions from which they are entered and which, with an area of 1,150 sq. ft., are lighted by a circle of eight 120-watt lamps, *i.e.*, 0·83 watts per square foot.

The side lighted galleries on the first floor, devoted to textile exhibits, are lighted by two rows of 3-amp. enclosed arc-lamps, 2 in series on 200 volts. These galleries are similar to those in the wood-work section just described, and the arcs are hung in corresponding positions to the 6-light fittings, but close to the ceiling. The floor-space, therefore, being 3,180 sq. ft. served by 14 lamps, the watts per square foot are 1·32, or nearly twice the amount used in the incandescent lighted galleries. The lighting effect is no better for this additional consumption, but it is necessary to employ arc-lamps in these galleries for the sake of judging the colours of the objects.

A good illustration of the absorption of light by dark-coloured walls is afforded by comparing these first floor galleries with those allocated to sculpture and stone-work on the ground floor at the eastern end of the building (Nos. 62, 64), which are of equal area and lighted by lamps of a similar size and number. The objects also are of the first of the classes just referred to—busts, statues, &c.—which depend for their beauty on the incidence of light and shade. In these galleries and those of the floor below there is a very objectionable multiplicity of shadows, particularly those of the upper part of the frames of the cases which frequently quite disfigure the sculptured forms. Care should, therefore, have been taken to arrange the lamps in the exact position necessary to best light each object, quite regardless of whether such points are at the intersections of beams or the centres of plaster panels : otherwise the objects ought to be arranged in relation to the lights.

Sufficient regard is frequently not paid to the importance of maintaining a similar direction of illumination by day and at night. The art museum, being intended to provide examples of all that is best in each art to be copied and studied, this is essential, for, if a student commences drawing some figure which by day is lighted from the right, and if at dusk he finds all the shadows suddenly thrown in the opposite direction, he immediately loses all benefit from the artificial lighting and the

museum might just as well be closed at dark. Utility is only too often sacrificed to symmetry in arranging both lights and cases.

In the day time it is possible to walk through these arc-lighted galleries without noticing the lamps which are hung high and enamelled white : on entering the galleries lighted by 6-light fittings, however, these form one of the most noticeable features.

The ground floor of the Long Corridor (No. 47), 500 ft. long by 16 ft. wide, is beautifully lighted by a line of 27-120-watt metallic-filament lamps under 10-in. conical opal shades at 14 ft. from the floor. As this represents only 0·4 watts per square foot of floor the abundance of light is rather surprising, but is no doubt due to the absence of objects in the centre of the corridor (the only exhibits being architectural drawing and photographs on the walls), to the whiteness of the walls, ceiling, and mosaic floor, and to the lamps being clear instead of obscured. Additional light from the arc-lamps in the large courts also shines through openings at several points.

The first floor corridor above this has a number of 7 ft. and 8 ft. cases arranged down the centre, and, as these required lighting on each side, 2-light electroliers having a 4-ft. spread have been employed. A fair light is the result, but the cases are too crowded together for them all to be well-lighted without considerably increasing the number of points. Probably, however, no very important objects are placed here, as it is by day one of the few poorly lighted parts of the building, the arched ceiling having a tunnel-like effect.

Some smaller rooms on the first floor at the west of the quadrangle, devoted to art engravings, are lighted by single-light pendants with 120-watt, clear, metallic-filament lamps. The four rooms, which communicate by large openings, are together 140 ft. long and 20 ft. wide, and are lighted by 10 such pendants, hanging at 10 ft. from the ground, in a single line. By this means a very good illumination has been obtained with inexpensive fittings and a very economical current consumption.

The lighting of the beautiful white-marble staircases at the Cromwell Road entrance has been done very successfully by 200 c.-p. obscured, metallic-filament lamps in ceiling fittings, in pleasing contrast to the more extravagant plan adopted in lighting the Exhibition Road entrance staircase with small arc-lamps.

In conclusion a word of praise should be said as to the special treatment given to various exhibits which have been built in the galleries, particularly a French boudior in Gallery 58, and a Swiss panelled room in Gallery 1 in the wood-work section, and the Santa Chiara Chapel in the East Hall, the lighting of which is by incandescent lamps concealed from view.

V. A. L.

The Visibility of Coloured Lights.

Red lights appear to be visible to a greater distance than green, according to *The International Railway Journal.* on recent tests on a clear, dark night, a red light of 1 candle-power was clearly discernible at 1 mile ; one of 3 candle-power at 2 miles ; 10 candle-power, through a binocular, at 4 miles ; and 33 candle-power at 5 miles. On an exceptionally clear night, a white light of 3·2 candle-power could be distinguished at 3 miles ; 17·2 candle-power at 5 miles. —*The Acetylene Journal,* March, 1909.

Lady Canvassers for Demonstration Work.

A recent number of *The Journal of Gas Lighting* refers to a suggestion made by Mrs. Helen Armstrong at the Chicago meeting of the National Commercial Gas Association last year, regarding the field of usefulness of ladies, acting as demonstrators for gas companies.

Ladies, it is pointed out, often possess qualifications which render them very successful in this field, and enable them to secure business which the business manager would, in the ordinary course of events, fail to recognize.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Recent Developments in Gas Lighting.

A REPRESENTATIVE of *The Illuminating Engineer* recently paid a visit to the premises of **Mr. Julius Norden** (44, Farringdon Street, London, E.C.), where a number of novelties in connexion with gas lighting are on view.

One of the first exhibits by which the visitor was struck is the display of a number of powerful incandescent gas lamps run on the "Pharos" high-pressure air system. Readers of this journal will recall a controversy on the relative merits of high-pressure air and high-pressure gas as a means of increasing the efficiency of incandescent gas lamps.* On behalf of high-pressure air it has been contended that the system can be applied to existing lower pressure gas installations without any change in the gas pipes being necessary, that no special meters are needed, and that the danger due to gas leakages is reduced, &c. There are two sets of pipes, one carrying to the burner the ordinary lower pressure gas and the other leading in air under pressure. At Mr. Norden's premises

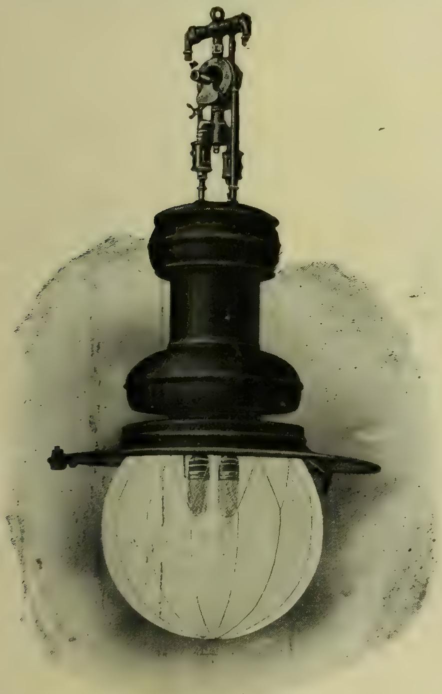


FIG. 1.—4,500 C.P. Pharos Inverted Light.

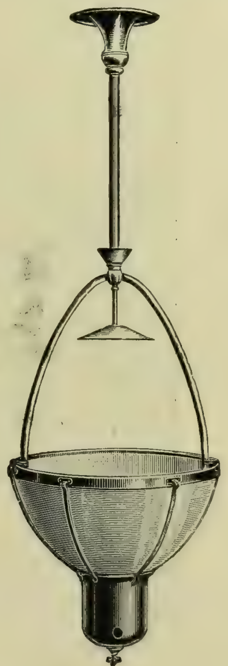


FIG. 2.—Semi-indirect fixture utilising Pharos Inverted Mantle.

* *The Illuminating Engineer*, London, Vol. I. 1908, p. 956.

an electrically driven compressor was shown at work compressing the air, and the course of the pipes carrying the gas and air respectively to the burner could be followed by the visitor; it was therefore an interesting object lesson in this system. Outside the shop was to be seen a powerful "Pharos" light stated to yield about 4,500 candle-power and about 70 candles per cubic foot. The lamp was also arranged with a special lowering gear and flexible tubes which have been for some time in use in Germany, but which, we understand, have not previously been shown in this country.* The lamp can be raised and lowered by means of a winch just like an electric arc-lamp, and without the supply of gas being interrupted. The process of lowering attracted an interested group of onlookers on the pavement.

Within the show-room are seen some smaller examples of the same kind of lamp, notably a semi-inverted fixture, which is shown in Fig. 2.

Lamps of this kind are stated to have found a wide application for drawing offices and other positions in which uniform illumination and absence of glare is essential in Germany. An installation of high pressure Pharos lamps will be seen in Fig. 3. All these lamps utilized uncollodianized mantles, and demonstrations were given of the method of burning them off.

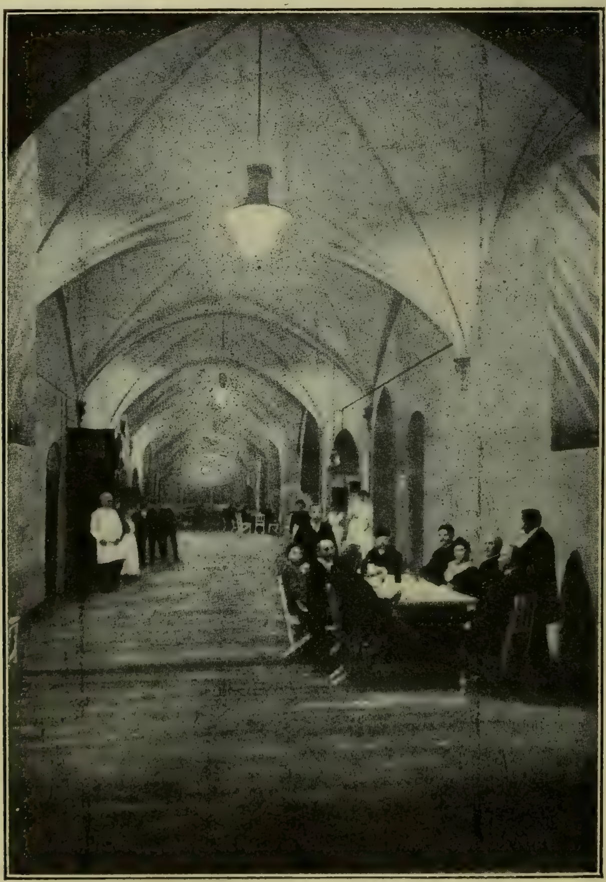


Fig. 3.—Restaurant lighted by Pharos Lamps.

There are also a number of other interesting details in connexion with these lamps, for example a special cylindrical lantern. This consists of two halves clamped together to form the complete cylinder; by releasing a catch the two portions come apart, and are readily detached for cleaning, &c.

Reference should next be made to a

* See *The Illuminating Engineer*, London, Vol. II., 1909, p. 639.

new form of distance lighter — the "Gascho"—which is illustrated in Fig. 4. The object of this device is to enable street lamps to be lighted and extinguished from the supply station by means of a temporary increase of pressure. This increase need not exceed three-quarters of an inch, in addition to the ordinary lighting pressure of, say, 2 inches, and the duration of the extra impulse is only about one to three minutes according to the distance. The apparatus is stated to be exceptionally simple and solid in construction and is entirely outside the gas chamber. The increase in pressure causes a leather membrane to rise. In so doing it moves a brass rod which actuates a cog-wheel above it. The teeth of this cog-wheel are cut in such a way that the first effect of a rise in pressure is to turn the light on. Subsequently, at a later time in the evening, a second impulse can be applied, and this in turn extinguishes the light. By a slight modification in the cog-wheel the arrangement can also be applied to a twin burner. In this case the wave of pressure can be caused to extinguish one burner only, and the second wave to extinguish both. This may lead to considerable saving in gas, for in many localities what is wanted is for the streets to be very brightly illuminated during a certain portion of the night, and then for a smaller amount of light to be provided later on.

Among other interesting exhibits may be mentioned portable incandescent lamps using methylated spirits and petrol respectively. A number of decorative fittings of a somewhat novel character were also on view; to some of these we hope to refer later.

Another development which was shown to our representative was a modification of the iron-cerium gas lighter described in a previous number of this journal.* This device, it will be recalled, consists in the use of a special mixture of iron and cerium which, when rubbed, gives rise to a spark. To operate the device two hands are necessary, one to grip the rod and the other to produce the brisk rubbing movement. Experiments are now being made with a simplified form in which the apparatus is gripped and operated by the same hand.

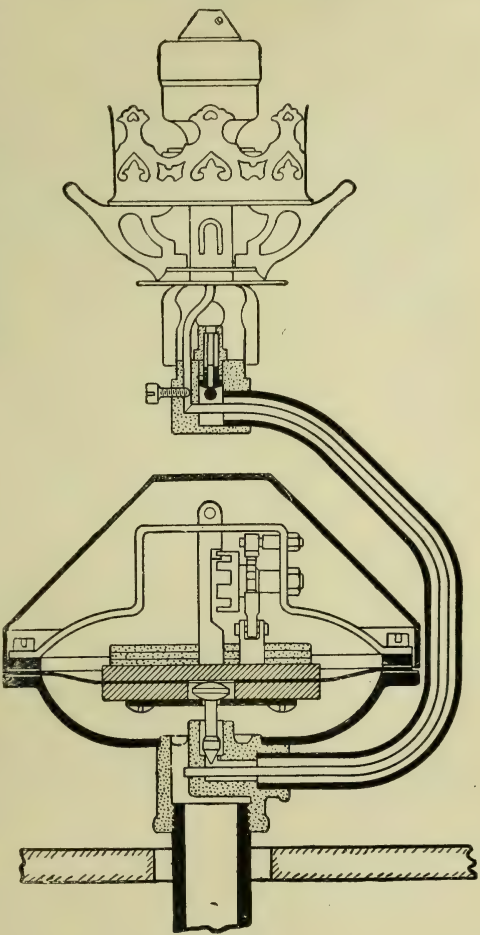


Fig. 4.—Sectional View of "Gascho" distance lighter.

* *The Illuminating Engineer*, London, Vol. II., 1909, p. 780.

From the **Machine Gas Syndicate, Ltd.** (180, Arlington Road, London, N.W.), we receive the most recent particulars and prices of the plants, on the Cox's Air-Gas System, manufactured by this firm. Attention to installations for from 30 to 150 lights listed at 32 to 105 guineas. The cheapness and convenience of the method for lighting are pointed out in a reprint of an article in *The World's Work* by Mr. Norman Wilson, and it is also stated that in remote districts the system has great advantages for heating and cooking purposes. Attention is again drawn to the demonstration of the absence of condensation in the pipes, even when they are immersed in a freezing mixture.

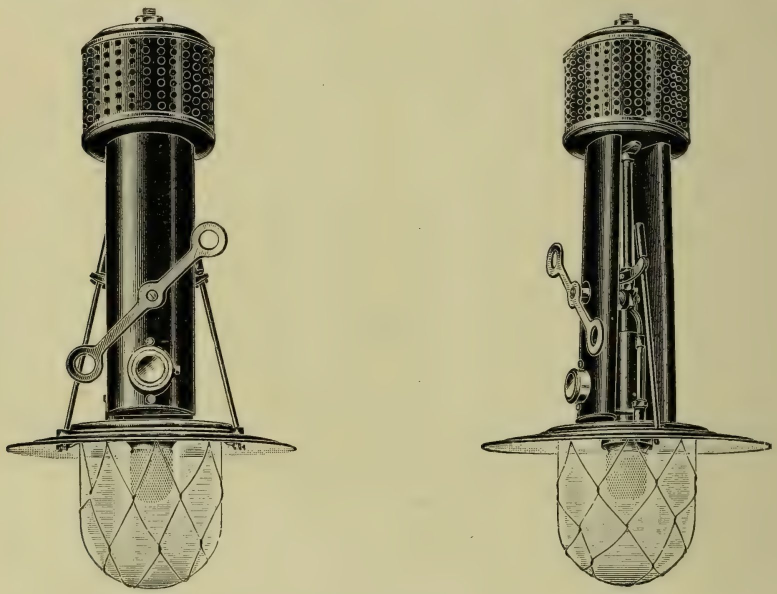
The New Inverted Lucas Lamp.

DURING a visit to **Messrs. Moffat's Ltd.** (13, Farringdon Road, London, E.C.) a representative of this journal was shown the new inverted self-contained lamp recently put upon the market by this firm.

Many different methods have been devised of producing a self-contained lamp such as can be burned off the ordinary low-pressure supply mains and yet enjoy the advantages of the intimate mixture of gas and air which the use of high pressure gas renders possible. One method of doing this, developed by Messrs. Moffats, was the thermopile lamp, which has been previously described in these columns.* Yet earlier the same firm made use of an elongated metal chimney with the object of producing a forced draught and consequently more perfect admixture of gas and air and an improved efficiency. This lamp, however, used an upright burner and mantle.

The new lamp represents a modification and improvement of this last principle. An inverted mantle is used and the single chimney is replaced by two separate ones which terminate at the head of the lamp and serve two distinct objects. One of the ducts leads direct to the burner and serves to draw in a stream of air from above, while the other, emerging in the globe surrounding the mantle, serves to carry away the products of combustion and produce the requisite forced draught. As soon as the lamp is lighted, therefore, a regular cycle of operations sets in, air being sucked in by the duct on one side and expelled by the other. Precautions are taken to prevent the expelled air being drawn in and again sent through the lamp.

A feature claimed for the lamp is that no wire-gauze is employed. Special arrangements are, however, made to avoid the possibility of the flame striking back—a defect which has to be specially guarded against in the case of most inverted lamps. It will be seen that the gas supply is led direct through the mixing chamber to the burner midway between the two chimneys. The burner is of special construction, terminating in a honeycomb of fine tubes. Uncollodianised mantles are employed.



FIGS. 1 and 2.—General View of New Lucas Inverted Lamp.

The lamp is stated to give approximately 1,200 candle-power and to yield about 40 candles per cubic foot of gas. In addition it is claimed that the arrangement of the chimneys renders the lamp wind-proof while the means adopted to secure improved efficiency are very noiseless. These advantages are often of no little importance in situations where self-contained lamps of this kind are employed. We understand that lamps of smaller candle-power than the above will be available shortly.

* *The Illuminating Engineer*, London, Vol. I., 1908, p. 583; Vol. II., 1909, p. 253.

The Lux Candle.

We have received from **The Lux Candle Co., Ltd.** (240, High Holborn, London, W.C.) particulars of a new type of electric candle which is claimed to be specially convenient for replacing existing fittings. The arrangement consists of an outer envelope surrounding the lamp proper, and it is only necessary to replace the long cylindrical lamp shown in Fig. 1, and not the surrounding cover. As the lamp itself projects above the opal tube there is no interference with the light, and the outer cover can be detached for cleaning without it being necessary to touch the lamp; the risk of breaking the latter is therefore reduced.

The general appearance of the candle will be gathered from Fig. 2.

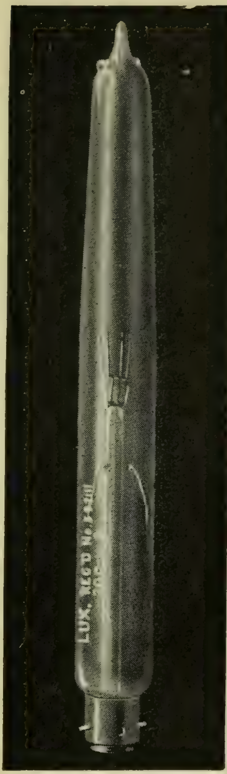


Fig. 1.

Fig. 2.

The "Multax" Long Burning Flame Arc Lamp.

This new lamp, which is put on the market by **The Globe Electric Co., Ltd.** (11, Farringdon Avenue, London, E.C.), is designed to meet the necessity of a long-burning flame arc. This is achieved, not by the use of two or more carbons, but by a special type of "Bridgecore" carbons.

It is claimed that by their use the burning hours of the existing flame lamp made by this firm are doubled without any increase in the length of the lamp being necessary; in addition, the increased strength of carbons tends to reduce breakages. The lamp is supplied in two patterns, intended for 20 to 36 burning hours respectively.

The British Thompson Houston Co., Ltd. (83, Cannon Street, London, E.C.), send us prices and particulars of Mazda electric incandescent lamps, which are now made for 200–250 volts, in the 32 watt 21 candle-power size, and are stated to run at 1·25 to 1·50 watts per candle.

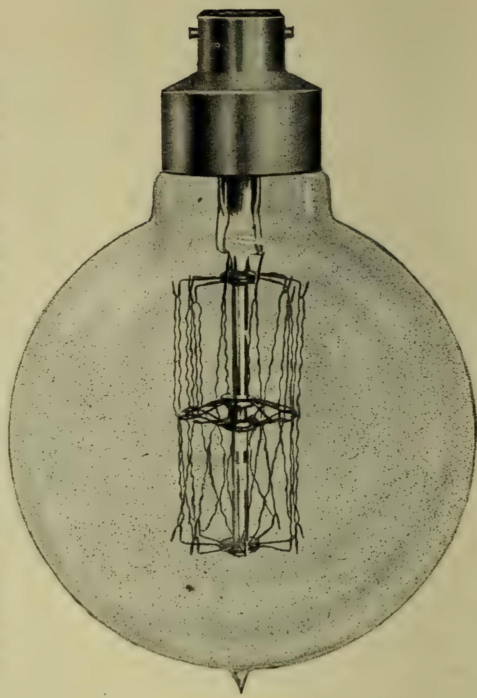
We have also to acknowledge the receipt of: particulars of the Wilkinson Economic Electric Stoves and Ovens (Messrs. F. A. Wilkinson, Harpenden, Herts), and particulars of the Mastico Bituminous Solution and Enamel (W. H. Keys, Ltd., 101, Leadenhall Street, London, E.C.).

The General Electric Co. (67, Queen Victoria Street, London, E.C.).—Particulars of electric water-boilers, toasters and foot-warmers.

The Union Electric Co. (Park Street, Southwark, London). — Particulars of "Union" shop-window fittings for use with metallic filament lamps.

The London Electric Treatment Institute (43–44, New Bond Street, London).—Descriptive pamphlet relating to use of electricity and light as curative agents.

The Siemens "Onewatt" Lamps.



Further particulars are now to hand regarding the new "Onewatt" Lamps which **Messrs. Siemens Bros., Dynamo Works, Ltd.,** Tyssen Street, Dalston, London, N.E., are placing upon the market, and which were referred to in our last number. The "Onewatt" is a "Tungsten" Lamp which has a filament of drawn "Tungsten" wire. The efficiency of the new lamps is the same as the average lamp of that type, namely, 1·1 watts per C.P. The present "Onewatt" Lamps are 100 C.P. for 100-130-volt and 200–250-volt circuits respectively, and are listed at the price of 4/6 each, subject to the usual trade and cash discounts. For street and shop lighting they are stated to be especially suitable and highly satisfactory results are confidently expected. These lamps, it is suggested, provide municipalities, contractors, and consumers with a lamp of very high efficiency at a low initial cost, thus reducing the maintenance and installation costs which up to now have considerably hampered the adoption of electric lighting in many cases.

The Necessity of Shading Naked Sources of Light.

A WRITER in a recent number of *Popular Mechanics* (October, 1909) gives a rather ingenious illustration of the need for reducing the intrinsic brilliancy of naked lamps. Many people, for example, are unwilling to use frosted lamps, being so strongly impressed with the amount of light lost thereby. "The beneficial effects of frosting," the author continues, "may be illustrated by the following whimsical parable :—

Gold, like artificial light, is one of the luxuries which civilized man has come to regard as a necessity. Suppose that gold descended in intermittent showers from the skies, and that in order for a man to possess any of the precious metal it was absolutely necessary for him to catch it with bare hands as it fell. It is safe to assume that the maiming effect of gold nuggets falling with express-train speed would detract largely from the pleasure of feeling them in one's hands. Now suppose that instead of descending in nugget form, the metal were beaten into gold-leaf, strips of which were dropped from the clouds and wafted their way down to the expectant hands of mortals below. Men would welcome such a change even if the amount of gold falling were decreased....As a general rule one can well afford to cut down his total lumens of light 19 per cent by frosting, when the same process reduces his lumens per square inch by several thousand per cent."

CORRESPONDENCE.

The Gas Industry and Illuminating Engineering.

Dear Sir,—It was with considerable interest that I read your editorial entitled 'The Gas Industry and Illuminating Engineering,' appearing in the March, 1910, issue of this journal. In common with you and others really interested in illuminating engineering, in its broad sense, I desire to see the gas industry take an active part in the work. You will note the word "take" —by this I mean that the gas industry should be sufficiently interested in the Art and Science voluntarily to make itself heard and not rely entirely upon those interested in illuminating engineering to create interest for them.

During the past couple of years there has been an awakening in the gas industry, especially in this country, and this is evidenced by the attitude of some of the larger gas companies towards the Illuminating Engineering Society.

Of this I may quote two concrete examples :—

When the Annual Convention of the Illuminating Engineering Society was held in New York City last year Mr. Walter R. Addicks, Vice-President of the Consolidated Gas Company of New York City, lent very considerable monetary aid, and did everything in his power to make the Convention a success, and in his remarks before the Convention showed that the Illuminating Engineering Society had been of material benefit to his Company. Mr. W. J. Clark, Vice-President of the Westchester Lighting Company, Mount Vernon, New York again, in his review of general progress during the past year said : "I think in no like period since the advent of the illuminating engineer has his art made such great strides as during the last year, particularly in the matter of gas lighting." (The truth of this remark was further substantiated by the holding of a joint meeting of the New York Section, Illuminating Engineering Society, and the National Commercial Gas Association at their Convention held in Madison Square Garden, New York City, in December.) "That the gas industry is awakening up to the importance of this factor in the satisfactory growth and output of its commodity is now unquestionable. A number of progressive companies have regularly employed men who are experts in illumination, and many of the gas companies who have not had their regular forces of illuminating engineers are making a practice of calling in the services of these trained men in the solving of lighting problems, &c..... I take some personal pride in having jointly called the attention of the gas men through my address to the National Commercial Gas Association two years ago, to the importance of the industry, and the great factor of illuminating engineering, and demanded the attention of the fraternity to this important field, and I trust that my humble efforts in this direction may have some weight."

It certainly would appear from the foregoing remarks that those in authority appreciate the value that broadly practised illuminating engineering principles may have on their industry, and it is my sincere hope that this feeling will expand until it is shared by all gas men, as well as electrical companies, acetylene companies, gasoline companies, &c., alike.

Believe me, &c.,

A. J. Marshall.

'Glare, its Causes and Effects.'

Dear Sir,—The recent discussion of the Illuminating Engineering Society on the question of glare revealed a general consensus of opinion that naked electric glow lamp filaments and other sources of great intrinsic brilliancy are often very improperly used. Permit me to mention a few illustrations.

As several speakers in this discussion truly stated, examples of the exposure of naked metallic filament lamps in show-windows are still very numerous. Until one takes a walk down some of our main streets with the object of studying this matter one hardly realises how few shops there are in which this defect does not exist, and how still fewer windows there are which can be said to be really well lighted.

In other cases high candle-power tungsten lamps have been used, and a marked improvement was recently instituted on some stations of the Underground by equipping such lamps with octagonal opal reflectors. This materially improved the illumination on the platform and at the same time screened the filament from the eyes of those waiting for the train. There can be no question of the improvement in comfort and ease in observing things which this modification has brought about.

In some cases a more or less unsatisfactory attempt has been made to screen the lamps in the carriages, but in others naked and antiquated carbon filament lamps still seem to be the rule. The accompanying sketch shows the appearance of some of the advertisements in these carriages with the lamps in front. When one attempts to read the notice the filament falls direct between the latter and the eye. One wonders how it is that, if the space devoted to advertisements is valuable, no stipulation is made that it should be so illuminated as to be easy to read.

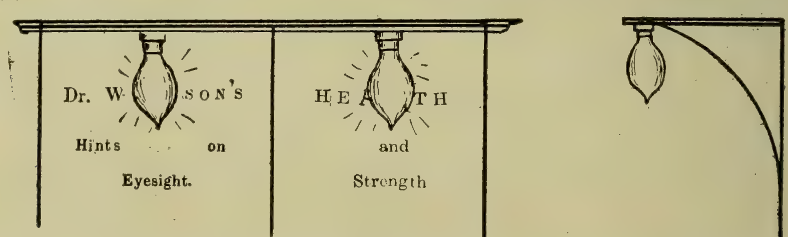


Fig. 1.—Showing Unsatisfactory Method of Illuminating Advertisements with Naked Lamps in the Direct Range of Vision.

Another example of glare is furnished by the arrangements on some of the tube railways. Many of these underground railways have recently shown commendable enterprise in putting up illuminated signs which are exceedingly good of their kind; they are characterised by a very satisfactory avoidance of glare and uniform brightness of surface. But it is surprising to find how often naked lamps are used in the trains or on the platforms. The writer has in mind one tube platform from which it is rarely possible to distinguish the time on the clock; the dial is not illuminated and usually appears jet black against the background of arc lamps and reflected light from the tiles.

Yet other instances of glare are furnished by certain of our public halls. In the Queen's Hall the lamps over the orchestra stalls are at least screened so that the audience cannot see them, though it cannot be said that this principle is adhered to throughout the building. On the other hand, in the Alexandra Palace, where a very large space is given up to the Orchestra and

choir, an objection might certainly be raised to the system of lighting employed. The illumination provided may be good and the lamps, regarded as efficient producers of light, may be admired, but it is a fact that people at the back of the hall cannot look towards the orchestra and choir without being acutely conscious of the brilliant unscreened high pressure gas mantles distributed over the auditorium. Probably the conditions could be materially improved by some simple screening device.

Other instances could, no doubt, be quoted. Occasionally, however, one finds a tendency of the opposite direction. I recollect a West End theatre in which the general illumination is certainly of a restful character, but so dim that in the pit it is literally impossible to read the programme provided. I am, yours, &c.,

DISSATISFIED.

Holophane Arcs.

We have received from the Holophane Co. (12, Carteret Street, Westminster, S.W.) their most recent catalogue of the Holophane "Arcs." The "arc," it should be explained, is a composite fitting, a group of glow-lamps being equipped with suitable reflectors and massed together, so range of candle-power available are also advantages. It is also recommended that when the lamps are placed at a height of less than 12 ft., lamps with frosted tips should be invariably employed so that anything in the nature of glare may be avoided.

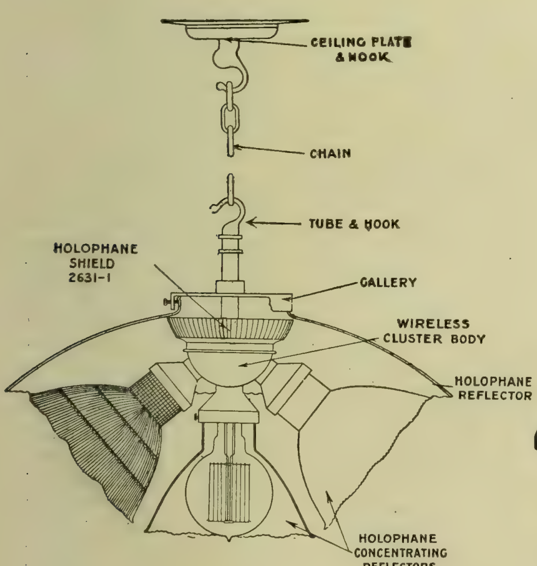


FIG. 1.

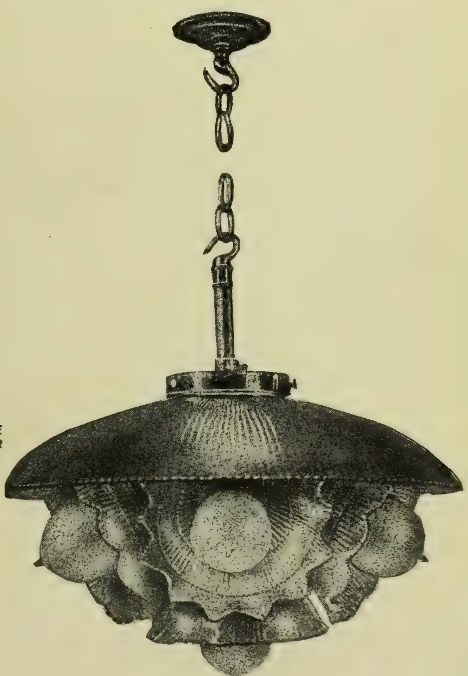


FIG. 2.

that the whole constitutes a single high candle-power unit. The general nature of the fixture will be understood from the accompanying illustrations.

By the use of these fixtures, it is claimed, the light is very efficiently distributed, and the steady nature of the source and

A feature of the catalogue before us to which special reference may be made is the list of spacing rules at the end, for the guidance of the contractor in securing good distribution of light in various kinds of interiors.

REVIEWS OF BOOKS.

The Distribution of Gas.

By Walter Hole.

(*John Allen & Co., The Gas World Offices, 8, Bouverie Street, E.C., Second Edition, 15s. net.*)

This is the second edition of Mr. Hole's work. It has been considerably extended and revised, and we note that seven new chapters, dealing mainly with the supply and consumption of gas at the consumer's premises, have been added.

This, of course, is as it should be. The rapid developments in gas lighting in modern times necessitate frequent revision of a work of this character. The result is a volume which will unquestionably be retained for reference by many of those interested even remotely in gas lighting; we need only echo the suggestion in Mr. Newbigging's introductory note to the effect that as long as the up to date character of the work is maintained it is not likely to be superseded.

The comprehensive nature of the book will be gathered from the fact that it contains over 800 pages, 33 chapters, and over 600 illustrations which, it may be added, are invariably clear and well executed.

In the course of the work a great many matters of a technical character are dealt with in some detail. The Discharge from Pipes, Governors, Mainlaying, Wet and Dry Meters, Gas Fires and Cookers, &c., all receive chapters to themselves. But the chapters which are of the greatest interest to us are Nos. XXI. and XXVII. to XXXI., which deal with internal and public lighting respectively. In the former it is pleasant to note that many of the points in connexion with illumination on which stress has been laid in this journal, are also emphasized by the author. In discussing shop lighting, for example, he points out, by the aid of illustrations, the absurdity of the reckless exposure of unscreened powerful lamps for advertising purposes outside shops and within the direct range of vision. He likewise advocates a mild diffused light for window illumination, and gives figures for the intensity desirable, adding "a strong glaring light may suit the cheap jeweller, but for good shop lighting it should be avoided at all costs." In this connexion the author makes special reference to the value of scientifically designed shades and reflectors. Mr. Hole is evidently conversant with the work of the Illuminating Engineering Society in the United States, quoting from a recent paper by Lansingh and Rolph in support of his views.

Mention may also be made of the chapter devoted to 'Complaints and Repairs,' in which the author, in addition to detailed instructions for repair and the detection of leakage &c., insists upon the desirability of cultivating friendly relations with the consumer.

The portion of the book devoted to public lighting deserves special study. The author describes the most recent high-pressure installations in London and Berlin, and makes reference to the views and experiments of Prof. Drehschmidt on street lighting. He also gives a brief summary of the chief points in the theory of the bunsen burner, and traces the development of public lighting by low-pressure, self-intensifying, and high-pressure systems. A serviceable summary of methods of distance lighting is also provided, and the design of lamp-posts is well illustrated.

The book closes with an Appendix tabulating the flow of gas through pipes and the diameter, which is reprinted from Mr. Newbigging's 'Handbook for Gas Engineers.' A satisfactory Index is provided—a very essential item in a book of this nature.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

There have been a number of editorials in papers in the United States dealing with various aspects of illumination. *The Illuminating Engineer* of New York, as usual, deals with a variety of subjects, such as A STANDARD OF WHITE LIGHT, LAMP-POSTS AS ARCHITECTURAL STRUCTURES, &c.

The Electrical World similarly deals with THE ARTISTIC IN LIGHTING, THE FLICKER PHOTOMETER, and other matters. One of the editorials referred to takes the view that the lighting experts must come, more and more, to cultivate the artistic side of the subject, if they are to be successful in any other than purely business offices, &c. Another matter dealt with in the same journal is the recent article by **H. E. Ives** on TESTS OF VISUAL ACUITY. The author explains a new system of gratings by the aid of which he can get a gradually adjustable fineness of detail for optical tests of eyesight, &c.

Among other articles of a more strict technical nature we may note that of **A. F. Parks** (*Elec. World*, N.Y., March 24) who deals with GRAPHICAL SOLUTION OF ILLUMINATION PROBLEMS. He points out that the calculation of the illumination produced at any point from a source of known polar distribution of light is an easy matter, so long as the source is symmetrically placed with reference to the plane illuminated. When this is not the case, however, calculations become more involved, and the author presents a chart of angles enabling the work to be simplified.

As usual, there are several general articles on SHOP WINDOW LIGHTING to record. **A. D. Curtis** (*Illum. Eng.*, N.Y.) shows how different types of reflectors can be arranged so as to throw the light into the window and avoid presenting the bright source of light to the people outside. Another article in *The Electrical Field* (April) discusses the subject more exhaustively, the author emphasizing the fact that when any source is installed it should be clearly borne in mind exactly what it is to do, *i.e.*, whether it is intended for general illumination, as an advertisement to attract custom, or to illuminate the goods in the window. Confusion of these three objects leads to undesirably glaring effects in shop lighting.

Among items of a more photometrical nature reference may be made to the discussion of the Illuminating Engineering Society (London), which is reported in many technical journals. The *Elektrotechnische Zeitschrift* (March 24) prints the recommendations of the Verband Deutscher Elektrotechniker relating to the measurement of the mean horizontal candle-power of electric lamps. The use of a rotating holder, or should this not be desirable, a mirror rotating round the stationary lamp, is recommended. Two alternative methods of making the actual photometrical test are given.

An article of general scientific interest is that of **W. R. Whitney** (*Elec. Rev.*, N.Y., April 14), who summarizes many of the known facts about the radiation of artificial illuminants, and entitles his communication THE CHEMISTRY OF LIGHT. Another recent paper dealing with radiation phenomena is that of **J. G. Clark** (*J.G.L.*, April 26). An interesting item in this paper is a series of polar curves of light distribution from incandescent mantles equipped with different kinds of opal shades.

ELECTRIC LIGHTING.

TUNGSTEN FILAMENT LAMPS continue to receive attention. A recent editorial in *The Electrical World* of New York draws attention to their increasing use for street lighting; in a second note the same journal contends that it is not desirable that metallic filament lamps of less than 20 candle-power should be generally used. The bringing about of a higher standard of illumination is more to be desired, and it is only in exceptional circumstances, *e.g.*, for the lighting of corridors and very small rooms, that lamps of smaller candle-power than the above are needed. *The Electrician* also deals with STREETLIGHTING by TUNGSTEN LAMPS, giving diagrams showing the life of lamps in various districts.

Another interesting note that may be referred to is that by Ashton in *The Electrician* (February 25). He proposes the use of CONDENSERS IN SERIES WITH METALLIC FILAMENT LAMPS on alternating

current circuits, in order that the voltage taken for the lamps may be reduced. Condensers have certain advantages over transformers for this purpose, as they are light, easy to make, and need only cost a few shillings. The fact that they give rise to a leading power factor would also be an advantage to central stations with more or less inductive loads. However, the author suggested that they cannot compete with transformers except in very small installations.

Turning next to Arc Lamps we may mention another reproduction of Wedding's article on the Timar-Dregar Lamps, in which horizontal flame carbons are used, and the length of the whole is greatly reduced. **W. H. Millar** (*Electrical World,* March 17) gives some particulars of the Quartz Tube Mercury Vapour Lamp now being used in France by the French Westinghouse Company. He gives its specific consumption as 0·25 watts per candle, and remarks that the colour of the light, on the whole, is pleasing while the mild and diffusing brightness of the illuminated outer globe is very restful to the eyes. Such lamps should be hung about 20 ft. high in the case of 1,000 candle-power units, and 30 ft. in the case of 2,000 candle-power lamps. Stress is laid on the fact that we have here available a high-candle power lamp in which the inconvenience of constantly renewing carbons is avoided.

Recent numbers of *Elektrotechnik und Maschinenbau* contain the usual account of Recent Patent Literature bearing on electric lighting, and the serial article in the *Zeitschrift für Beleuchtungswesen* relating to the detailed construction of metallic filament lamps, the attachment and methods of winding the filaments, &c. is continued. **J. R. Pollock** (*Zeitschrift für Beleuchtungswesen,* April 20) and others have published a paper dealing with the phenomena which occur when a carbon arc is suddenly switched off and then switched on again. Curves are published connecting the voltage across the arc and the time in seconds during which the lamp is switched off.

A very striking editorial in the *Electrical Review* for April 1st points out, the importance of illuminating engineering to the contractor and explains the province of the expert illuminating engineer.

Lastly reference may be made to some of the practical applications of electric lighting. Among these may be mentioned the Electric Lighting of the New Theatre in New York (*Elec. Review,* New York, March 19), and the article by **T. J. Jones** entitled Electricity in a Modern Restaurant (*Electrical World,* New York, March 10); in the former some massive forms of chandeliers equipped with small frosted lamps are shown, and in the latter the decoration of the restaurant ceiling with miniature lamps concealed amid artificial vegetation of bunches of grapes, &c. **J. R. Sloan** (*Elec. Review,* April 2, 9) deals with Electric Car Lighting, his article being mainly concerned with the practical arrangements and different systems of placing the generator on trains, &c. Yet another contribution of the same kind is that of O. D. Ziegler in the April number of *The Illuminating Engineer,* New York, who deals with various types of Animated Electric Signs.

GAS, OIL, AND ACETYLENE LIGHTING.

One matter, in connexion with gas lighting, which has received a considerable amount of attention in the British technical press during the last few weeks has been the decision of the Westminster and City Council regarding the Lighting of the Streets in the neighbourhood of Piccadilly. This locality is to be lighted by high-pressure incandescent gas lamps of 1,800 and 3,000 candle-power, instead of the electric arc-lamps previously employed. A feature of the contract is that a penalty of 5*s.* per day per lamp in the case of large lamps, and 6*d.* per lamp in the case of small ones, is to be paid by the gas company in the event of the light of such lamps falling below the prescribed value. The electrical journals naturally comment on this decision extensively the general impression being that the low cost quoted for the upkeep of the gaslamps indicates that the installation is to be regarded mainly as a good advertisement.

The Bill now before Parliament for a Common Testing Burner has already received much attention. In this connexion the question whether both a colorific and an illuminating test is necessary has been much debated. Mr. Corbet Woodall gives his opinion that either one standard or the other ought to be adopted, but not both; in Germany reliance is now placed almost exclusively on a colorific test, and this is natural since 90–95 per cent of the gas generated is usually employed either for heating or with incandescent mantles (*Journal of Gas Lighting,* April 12th, *Gas World,* April 16).

Several papers in the United States by **E. J. Bean, A. B. Burr,** and **F. Blyler** refer to various phases of illuminating engineering of interest to the gas engineer. **E. J. Bean** for example describes a

number of SINGLE UNIT INSTALLATIONS. He presents plans of the system of illumination adopted in various buildings and gives the result in terms of Lumens per unit area. The use of the term "Lumen" seems to be becoming premanently fixed in American practice.

There will also be found in the British press references to a number of new forms of automatic gas lighters. Thus *The Journal of Gaslighting* (April 19th) refers to the "Gascho" apparatus put on the market by Julius Norden, and in a previous number, to the Broadberry device, both of which act by the application of a temporary increase of pressure. A feature of the latter apparatus is the provision of artificial liquid inertia; as a result of this the apparatus only responds to a *steady* change of pressure and is affected by small transitory fluctuations. A very novel suggestion is referred to in a recent number of *The Gas World, i.e.*, the possibility of controlling street lamps by wireless electric waves, on a resonance system; the apparatus does not seem to have materialized yet, however, and this is only a suggestion. Among other articles we may refer to that by **Mr. W. Grafton** dealing with GAS COMBUSTION AND TESTING BURNERS (*J.G.L.*, April 5th, *G.W.*, April 9th).

In recent numbers of the *Zeitschrift für Beleuchtungswesen* there are also accounts of new forms of inverted burners and incandescent burners utilizing alcohol and petrol, &c.

A number of rather interesting articles relating to developments in acetylene lighting should also be mentioned. Thus **P. Rosemberg** (*Revue des Éclairages*, March 30th) refers to a recent decision of the police in Paris that dissolved acetylene outfits may be used as a system of emergency lighting in theatres, and he describes an installation of this kind. **H. Gallus** in the same journal refers to the application of powerful portable acetylene lamps in building operation and loading ships, &c. Another writer in *Acetylene* deals with railway carriage lighting, and describes the utilization of dissolved acetylene in connection with incandescent mantles.

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Acetylene, the Best Light for the Eyes (*Acetylene*, April).
Petrol Gas Machines from the Standpoint of Safety (*Acetylene*, April).
Innovations in Acetylene Inverted Lighting (*Acetylene*, April).
The Standard Automatic Gas Controller (*G.W.*, April 2).
Neue Invertbrenner (*Z.f.B.*, April 10, 20).
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CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*

E. T. Z.—*Elektrotechnische Zeitschrift.*

G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. G. L.—*Journal of Gaslighting.*

J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

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EDITORIAL.

KING EDWARD THE VIIth.

DURING the past month a great loss has been suffered by the Nation. The sorrow of the British people, in the removal from their midst of King Edward, will be shared by those in other countries who knew and recognized his wide and tolerant sympathy, his services to humanity, and the qualities which earned for him the title of "The Peacemaker."

It may well be said that in this term, more than any other, the guiding principle of King Edward's reign will be made known to posterity. It is not too much to say that all in this country, rich and poor alike, thought of King Edward as a personal friend. It was also a most striking testimony to his sagacity as a ruler, and to his kindly and lovable disposition as a man, that King Edward, while inspiring the utmost loyalty and devotion in his own subjects, yet came to receive the friendship and confidence of the whole civilized world. Among scientific men, who have learned to place high value on international co-operation and mutual service, his efforts in promoting the brotherhood of nations will be long remembered with grateful appreciation.

Fortunately we have every reason to hope that the influence of King George V. will be exercised in the same beneficient direction. He has more than once given convincing proof of his personal enthusiam for the cause of science, and of his recognition of the importance of scientific thought and method, as the firm basis on which the prosperity of the nation must rest.

The first Annual Meeting of The Illuminating Engineering Society.

WITH the first Annual Meeting of the Illuminating Engineering Society on the 23rd of last month the first session of the Society comes to a close.

Our readers will find on p. 379 the full report of the Council for the session, in which the progress of the year is summarized. It is, however, interesting to look back over this period and to observe how fully most of the original anticipations of those responsible for the formation of the Society have been justified. The few who initially feared for its ultimate success seem to have been impressed either by the supposed difficulty in securing harmonious working between representatives of different systems of illumination, or by an assumed lack of sufficient material to discuss. It need hardly be said how completely these suggestions have been disposed of in our first session.

Meetings and discussions have invariably been of an amicable character and all members interested, whatever the trade or profession which they represented, have worked together to make the Society successful. As regards material for discussion the only difficulty has been that the subjects treated proved far too rich in suggestion to be dealt with completely in the time at our disposal, and there is a vista of sufficient useful work to keep us engaged for several years.

As explained in the report, the efforts of the Society, during the past session, have been mainly devoted to the widening of its scope of action, and to interesting the general public in its aims and objects.

The Meetings during the session were devoted mainly to the discussion of two broad questions, namely 'Glare, its Causes and Effects,' and 'The Measurement of Light and Illumination,' which were such as to appeal to the members of the Society as a whole and which, clearly, had a direct bearing on all problems in illumination. As a result some very stimulating discussions took place, and the Society was successful in inducing a number of representatives of the medical and other professions to take an interest in its deliberations, many of them subsequently becoming members. For the rest the report of the Council makes it clear that an increasing amount of space has been devoted in the press to the subject of illumination and the doings of the Society. The membership of the Society has increased from 150 to 225, which is certainly very gratifying progress for the first session. It is, however, even more satisfactory to observe that the Society now includes among its members so many distinguished authorities in this and other countries,—a number indeed which few, if any, other similarly constituted Societies could have shown at so early a stage in their careers.

And, lastly, it is with special pleasure that we observe that Prof. S. P. Thompson has kindly consented to accept the presidentship for a second year of office. During the past year the Society has owed its success very largely to his influence, and to the benefit derived from his constant advice and assistance. The next session of the Society should therefore start under the very best auspices and we hope that, during the vacation, each member will make a personal effort to induce others to join and to make the aims and objects of the Illuminating Engineering Society yet more widely known than at present.

Recent Developments of Photometrical Instruments.

One interesting feature of the Annual General Meeting was the exhibition of two simple and portable photometrical instruments by Mr. Haydn T. Harrison and Mr. J. S. Dow. The description of both these instruments will be found on pages 373-376. Mr. Harrison explains that his is a direct reading apparatus which enables an idea of the illumination at any spot to be readily formed by the mere inspection of the scale without it being necessary to make

any adjustments. The instrument devised by Mr. Dow and Mr. V. H. Mackinney is mainly intended to measure the "intrinsic brilliancy" or "surface brightness" at any point. By its aid, it is suggested, the brightness of any surface could be estimated by inspection from a distance and this should be advantageous in cases in which one cannot readily get access to the exact spot where the measurement is to be made.

In these cases the attempt has been to secure, above all, simplicity and portability rather than an excessive order of accuracy.

These experiments may be said to be the result of the recent discussions of the Society on the 'Measurement of Light and Illumination.' We need not say that we should be glad to hear of any other such devices that may be developed during the vacation. It is coming to be recognized that in methods of measuring illumination, as in other matters, there is room for a wide variety of different forms of instruments, all having their distinctive spheres of action.

What is mainly needed is that the measurements of this kind should come to be looked upon as simple and familiar processes. Naturally our present apparatus is not perfect, but the more extended use of existing instruments will reveal to us where their weaknesses lie and what errors are likely to be involved in their use. By this means we may expect to see a steady improvement in accuracy and reliability, which, in turn, will be stimulated by an increasing demand as the value of numerical data on illumination come to be better appreciated.

Researches on Metallic Arc Lamp Electrodes.

The article by Dr. B. Monasch on the above subject, commenced in the April number of *The Illuminating Engineer* and continued in our present issue, deals with a subject which is still very imperfectly understood. The author shows how in the early history of arc lamp design there were many misconceptions as to the physical laws underlying the electric arc, some of them probably not entirely cleared up even to-day.

In particular it is interesting to notice how there was a tendency to apply to arc lamp electrodes the same principles which were understood to underly the success of incandescent filaments. It was assumed, for example, that hard refractory materials and oxides of the rare earths such as would withstand a higher temperature than carbon (for example, alumina, fireclay, and the materials used in the Nernst lamp) would form a good basis for electrodes of arc lamps and give rise to a very efficient result. Experience shows that this is not the case. Dr. Monasch's experiments with Nernst material do not lead him to hope for any great improvement in efficiency by this means. He has also examined the effect of using various combinations of the less known metals with a magnetite core electrode, on the nature of which the luminous efficiency and colour of the flame mainly depend. The majority of the large number of substances examined do not give very hopeful results; that is to say, their addition to the core leads to a diminution in candle-power and the pure magnetite would have given a better result. But there are certain metallic oxides, such as those of titanium, vanadium, &c., which, when mixed with the magnetite, lead to an improved luminous efficiency. By a careful study of these effects one may expect to arrive at a combination which gives the best result both from the standpoint of light-production, and — what is equally important — as regards durability. In arc-lamps with metallic electrodes one's aim should presumably be to secure high luminous efficiency and yet, at the same time, to produce electrodes which only waste away very slowly so that the lamp can burn for a long time without requiring attention.

Yet another item to be considered is the nature of the spectrum of the light given out. We should seek to secure not only a high luminous intensity, but a colour and quality of light which is satisfactory from the hygienic standpoint and beneficial in its influence on vision.

The Sale of Gas Appliances and Illuminating Engineering.

On page 405 we refer to a very interesting and valuable booklet issued by Mr. Norman Macbeth, illuminating engineer to the Welsbach Company in the United States. Those who are still unconvinced regarding the value of scientific knowledge of the distribution of light from different forms of lamps would do well to study the 'Data on Illuminating Engineering' which he presents. In this little book photographs are provided of a number of different gas lamps, each equipped with its proper shade and reflector, and each photograph being followed by a curve and table showing its distribution of light and giving full particulars of its mean spherical and mean hemispherical candle-power, output in lumens, &c. Armed with exact knowledge of this kind an engineer can predict with much greater exactitude what any particular lamp will do or will not do in practice. The design of lighting installations then becomes definite and scientific instead of the results of illumination being left more or less to chance. It is also to be noted that Mr. Macbeth lays special stress on utilizing each lamp with its appropriate shade, and on the desirability of suppressing the glare which is apt to be a feature of powerful incandescent mantles only surrounded by a clear glass globe.

Of equal interest is the handbook for the benefit of canvassers in gas appliances. In this little book Mr. Macbeth rightly lays stress on the desirability of reference to published scientific papers on the subject in advocating the claims of gas appliances. It is this capacity to lay hold of and apply the most recent researches and results in illuminating engineering that leads to success.

The Coming International Medical Congress at Brussels.

There is one item in the Report of the Council of the Illuminating Engineering Society which has attracted considerable attention, namely, the reference to the participation of the Society in the above Congress.

As has been pointed out in this journal (Feb., 1910, p. 88), the occasion forms an interesting precedent since, for the first time, the practical aspects of factory and workshop lighting and the measurement of light and illumination are to be considered in connexion with defects of vision and the health of employees. It may be added that at this stage of our knowledge detailed information regarding the effects on workers of different systems of lighting, and definite instances of cases in which certain methods of lighting have been clearly proved by their results to be satisfactory or the reverse, would be very valuable. Our Society was therefore very pleased to accept the invitation of the Congress to be represented officially, and to take part in the discussion. We hope that in the future the Society will be able to avail itself of many similar opportunities of drawing attention to the claims for good illumination. Thus we shall aim at obtaining the official support of those able to utilize the information which we may supply as a result of the concerted efforts of the oculists, architects, and engineers. We shall look forward to the proceedings of the Congress with great interest and wish it every success. LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 367) gives an illustrated account of the MARTENS ILLUMINATION PHOTOMETER. He also refers to the use of shutters and diaphragms as a means of adjusting the illumination of the photometric surface according to a uniform law. This method is used in the Simmance-Abady Street Photometer.

Following this will be found an account of the FIRST ANNUAL MEETING of the Illuminating Engineering Society (p. 371). The first part of this meeting was devoted to purely formal business, including the reading in abstract of the Report of the Council for the Session 1909–1910. The nomination of three new members of Council was announced, and two minor alterations in the Constitution of the Society adopted. Prof. S. P. Thompson kindly consented to continue in office as President of the Society for another year.

Mr. Haydn T. Harrison and **Mr. J. S. Dow** described NEW FORMS OF PHOTOMETRICAL APPARATUS. The instrument exhibited by Mr. Harrison involved the use of a semi-transparent graduated scale illuminated from behind with a varying intensity according to a combined inverse square and cosine law. The characteristic of the instrument is that the illumination at any place can be read off direct without any manual adjustment of its parts being necessary. It is also adapted to the measurement of illumination at any desired angle.

The instrument shown by Mr. Dow is intended mainly to measure the intrinsic brilliancy of any bright surface; this is looked at through an aperture in an illuminated white screen. The illumination is varied by a couple of moving shutters travelling in front of an opal glass plate lighted up by a small glow-lamp. By means of this instrument it is hoped to estimate the brightness of a distant surface to which it is not easy to get access. One can also readily determine the relative reflecting powers of different materials.

On p. 379 will be found the REPORT OF THE COUNCIL FOR THE SESSION. A summary is given of the work of the past year, and it is pointed out that there is every reason to hope for continued success. Since the inauguration of the Society there has been a marked growth of interest in matters connected with illumination and the proceedings of the Society receive an increasing share of attention. The membership has increased from about 150 to over 225. Stress is also laid on the co-operation of distinguished authorities on the Continent and in the United States, and it is hoped that in the future the international connexion of the Society will be found yet more beneficial. It is anticipated that the programme for the next session will be of an attractive character, and that papers on such subjects as street, library, and shop-lighting will be presented. Following the report of the council will be found a continuation of the discussion THE MEASUREMENT OF LIGHT AND ILLUMINATION in which **Mr. G. F. Boxall** contributes some remarks.

The discussion on Dr. Sumpner's paper on THE MEASUREMENT OF THE TOTAL LIGHT FROM A SOURCE is commenced on p. 387. **Prof. Ulbricht** and **Dr. L. Bloch** give their reasons for supposing that the Ulbricht globe is preferable to the cubical box proposed by Dr. Sumpner, and argue that the latter is certain to introduce considerable errors—especially when sources having non-symmetrical polar curves of light distribution are studied. **Prof.**

G. W. O. Howe describes an attempt to construct and use a box of the type advocated by Dr. Sumpner, at the Central Technical College, and gives particulars of some experiments which suggest that it can be satisfactorily employed with commercial sources of light. **Mr. J. S. Dow** also discusses the errors involved in the use of a cubical box, and suggests that these may be found to be less serious if it is very large. **Dr. W. E. Sumpner** replies to the various criticisms and suggestions (p. 392).

Dr. B. Monasch (p. 394) continues an account of some researches into the properties of Metallic Arc-lamp Electrodes. In the present section he studies the shape and colour of the flame obtained by the use of various materials, of which titanium, vanadium, and other oxides seems to give the best results. He describes an experiment with an arc struck between electrodes of Nernst material which shows that the bulk of the light in these circumstances came from the electrodes and very little indeed from the luminous flame.

On p. 399 will be found an article on Shop Window Lighting, in which some illustrations of successfully lighted premises, exhibited at the recent exhibition in Berlin, are given. The distinction is drawn between the modern view of a window as a place where specially attractive and choice articles are exhibited, and the older conception of a window as a "catalogue" of the goods within. The latter method inevitably leads to overcrowding and renders it difficult to obtain any truly artistic effect. When, however, the window is regarded as a picture the value of good lighting and arrangement becomes evident. In the higher classes of show window illumination there is room for the services of an expert who is skilled both in the artistic arrangement of the goods, and also in the use of light to display them to the best advantage. The required specialist must understand both window lighting and window dressing.

Another article dealing with the artistic side of lighting commences on p. 407. In this contribution Some Architectural Considerations affecting the Design and Position of Lamps and Fixtures are discussed. It is shown how the position of a source may be decided by artistic "balance" rather than by considerations as to where the light is needed. The proportions of fixtures, again, may be determined by symmetry with the interior quite apart from the functions of the source as an illuminant. In the case of outdoor lamps, it is also suggested, more might often be done to reconcile the artistic view with purely utilitarian considerations. To-day, with our powerful and efficient illuminants we are in danger of disregarding the former possibilities.

A contribution by **Dr. L. Bloch** (403) summarizes the recent recommendations of the Photometrical Committee of the Verband Deutscher Elektrotechniker regarding the Measurement of Illumination in streets and interiors. They propose a common system for both cases, namely, measurement of the horizontal illumination at a height of one metre above the ground or floor, and give full reasons for this suggestion. This proposal is to be submitted at the Annual Meeting for tentative trial for one year, and it is also being placed before the Verein von Gas und Wasserfachmännern with a view to its adoption by the gas industry.

Reference may lastly be made to a note on some publications, for the use of canvassers, &c., by **Mr. N. Macbeth** of the Welsbach Gas Co. in the United States. The Engineering Data, comprising a series of photographs of different types of gas lamps, each accompanied by its respective polar curve of light distribution, is exceptionally noteworthy, and the book of hints to canvassers is also of interest.

At the end of the number will be found the usual Review of the Technical Press.

Illumination, Its Distribution and Measurement.

By A. P. Trotter,

Electrical Adviser to the Board of Trade.

(*Continued from p. 295, Vol. III.*)

The Wingen Photometer.—The illumination photometers which have been described have horizontal screens or test plates receiving light from every direction with no obstruction except that of the observer's body. For the general illumination of interiors it is necessary that the test-plate should command a wide view. Several instruments have been designed for measuring the illumination on desks, which receive light principally from windows in one direction. An instrument of this kind was designed by A. Wingen, and has been made by Krüss of Hamburg. It consists of a box containing a benzine lamp which illuminates a white screen in the box, and this is compared with another screen just outside the box. The illumination is balanced by altering the height of the flame of the benzine lamp, and this height is measured on a scale. This somewhat primitive arrangement has been improved by the adoption of my moveable screen and cam. The arrangement is shown in Fig. 120. The height of the flame of the benzine lamp is adjusted to a gauge line. The eye-piece inevitable in German instruments, gives a view of the test-plate S, which receives the illumination to be measured, and of the inner moveable screen V. This rests on a cam H of such a shape that approximately uniform angular movements of the shaft on which it is fixed give uniform alterations of the illumination of the moveable screen. The range is from 10 to 50 *meterkerzen*, or from 0·93 to 4·65 foot-candles. Tinted glass screens sliding in the eye-piece are used to increase this range.*

The Martens Photometer.—This is another instrument employing a benzine lamp, and having a test-plate of plaster of Paris intended to receive light mainly from above or in one side direction, other directions being obstructed by the instrument as in the Wingen Photometer. Fig. 121 is a diagrammatic view of the arrangement which cannot be shown in simple plan, as the parts are arranged at various angles. Fig. 122 is an end view, showing only the essential features. The benzine lamp L is fixed, and its light is reflected by a pair of mirrors M on to a prism, which reflects it on to a ground-glass screen G. On looking through the eye-piece, the image of this screen is seen alongside an image of the white screen S. The most original part of this apparatus is the use of the pair of mirrors for altering the illumination. Even with the double effective length of travel which these provide, tinted screens must be used to give a useful range.

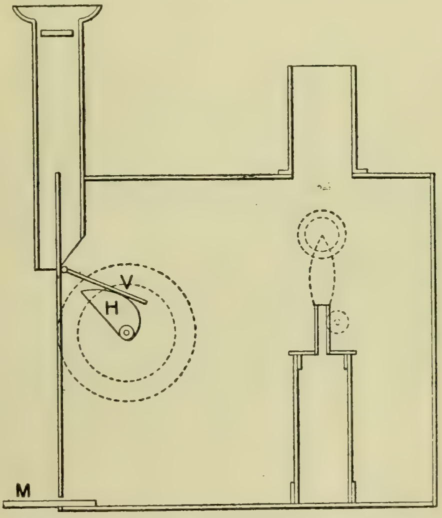


Fig. 120.—The Wingen-Krüss Photometer.

Iris Diaphragm Photometers. — A photometer was made some twenty-five years ago by Petruschewsky for measuring the illumination on school desks.

* Fully described in *Journal für Gasbeleuchtung*, 1902, p. 738, and *Journal of Gaslighting.*

The light from an oil lamp was cut off by a diaphragm having a tapering aperture. Blondel and Broca have used a "cat's-eye" diaphragm. My unsuccessful attempt to use this device has been mentioned, but I applied it simply to a small glow-lamp, and when the light was cut down for measuring feeble illumination, the diaphragm acted as a pinhole, and gave an image of the filament. Blondel and Broca place an opal glass screen between the lamp and the diaphragm and avoid that difficulty. Their photometer has been so recently described in these pages that further details need not be given.

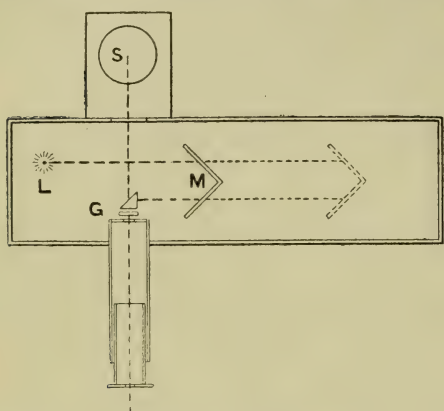


FIG 121.—The Martens Photometer. Diagrammatic Plan.

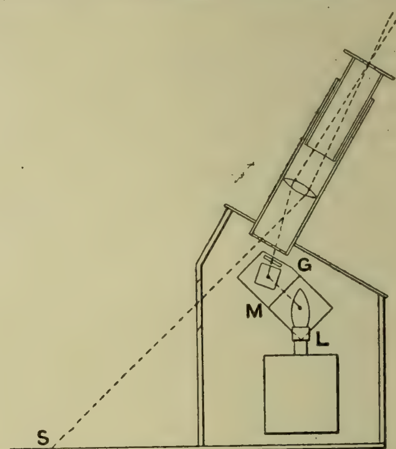


FIG. 122.—The Martens Photometer. End view.

This principle has been used in the Simmance-Abady photometer, with the intention of employing a simple law and avoiding experimentally graduated scales. A small electric glow-lamp is employed, but this is not used directly. It illuminates the interior of a small globe whitened inside. The light diffusively reflected from one side of this globe illuminates a flicker photometer and the area of the surface exposed to the photometer is controlled by an iris diaphragm. This claims to be a direct reading instrument. The use of the flicker photometer renders the apparatus unsuitable for low illuminations, and like the Harrison instrument it is intended mainly for candle-power photometry. When used for illumination a reflecting screen is used somewhat in the same position as that of the Martens photometer. The Simmance-Abady photometer with its accessory apparatus is carried about on a wheeled carriage.

(*To be continued.*)

Forthcoming Papers before the Illuminating Engineering Society in the United States.

WE note that several papers of exceptional interest are to be read at the next meeting of the New York section of the Illuminating Engineering Society on Thursday, June 9th.

Dr. E. B. Rosa, of the Bureau of Standards, Washington, will present a paper on "Photometric Units and Nomenclature" and Dr. C. H. Sharp and Mr. P. S. Millar, of the Electrical Testing Laboratories of New York City, will deal with "Incandescent Electric Lamps as Secondary Standards of Luminous Intensity." At this meeting the annual election of officers will also take place.

A Novel Physiological Effect.

A very interesting effect was recently described by Prof. S. P. Thompson in a paper read before the Royal Society on April 14th. The physiological effects of the electric current have, of course, been known for many years, but it has been left to Prof. Thompson to show for the first time the existence of a distinct magnetic effect.

The experiment in question is as follows. A powerful solenoid, of sufficient diameter to enable the observer's head to be inserted, is stimulated by an alternating electric current producing a powerful concentrated pulsating magnetic field. When the head is placed in this field the observer at once becomes conscious of a throbbing flickering sensation coupled with a general impression of faint luminosity spread over the field of vision. It seems to be assumed that the effect of the pulsating field is to be ascribed to induced currents. So well marked is the effect that it is experienced even in daylight. In order to render the phenomenon very evident, however, an exceptionally powerful dense field is needed and this may partly explain why the effect has hitherto been overlooked.

It is nevertheless interesting to note that, according to *The Electrical World* of New York, there were, even twenty years ago, certain people who professed to be able to see when a magnet was excited, though their claim does not appear to have been substantiated. In this case, however, it seems to have been a steady and not an intermittent field so that the effect, if it really existed, must have been of a different kind. A more probable instance of the previous experience of the sensation is that furnished by the evidence of certain workmen in nitrate factories who declared that they could see a faint flame above the large coils when they were excited by a powerful alternating current.

It is perhaps appropriate that this visual effect should have been discovered by the First President of the Illuminating Engineering Society. It certainly illustrates the fact that there may exist, unsuspected by us, physiological effects due to ethereal disturbances—possibly effects of vital importance. We have frequently referred in these columns to the possibility of peculiar kinds of radiation, such as, for example, the ultra violet rays exerting an influence on the human organism, just as the Röntgen rays are now known to do. It will also be recalled that but a short time ago a discussion took place regarding the possibility of physiological action on the part of wireless electrical waves.* In experimenting with new forms of energy, therefore, this possibility should be borne in mind, and, at far as possible, due precautions taken.

* *Illum. Engineer*, London, Vol. II., 1909, p. 278.

Eyesight in the Territorial Force.

Something like one-third of the men in London who present themselves for enlistment in the Territorial Force have to be rejected owing to some physical defect, and that defect is generally of vision, said Col. H. S. Coldicott, of the Rangers.—*The Standard*, Jan. 24th, 1910.

The Second Municipal and Public Health Exhibition.

The Second Municipal Health Exhibition was held at the Royal Agricultural Hall, London, from May 7th to the 14th. The first exhibition, held in 1908, is stated to have been the first attempt to provide a display devoted to municipal interests.

The exhibition was the means of introducing to those concerned with municipal matters a number of novelties in connexion with sanitary work, road-making, and such matters. Special interest was shown in the Model Municipal Cottage designed for the exhibition by Mr. E. C. P. Monson, F.R.I.B.A., F.S.I., which was stated to cost only £160 to £175. The internal and external walls and partitions were stated to be entirely fire-resisting and vermin-proof, being constructed of "Mack" plaster slabs. Other features in the cottage were the provision of special hot-water ranges and cooking facilities. Among other exhibits may be mentioned water-proofing, Doulton steel stoneware piping, road materials, steel shelving, &c.

One could have wished that lighting apparatus had been more fully exhibited, but gas and petrol-air gas were represented by the exhibit of the Praed Patent Safety Gaslight Co., in which a mixture of petroleum vapour and air is manufactured and utilized. Reference was made to the system in this journal on the occasion of the previous exhibition in 1808.*

Messrs. Moffats, Ltd., also exhibited a number of their most recent types of street lamps, including the new 1200 C.P. self-intensive type, which was also recently described.† Yet another gas novelty was the "Automaton" lamplighter, a new method of distance lighting by a rise in pressure, which is dealt with elsewhere in this number (see p. 411).

* *Illum. Eng.*, Lond., Vol. I., June, 1908, p. 488.
† Vol. III., May, 1910, p. 350.

Lighting a Rifle Range.

An interesting problem in illuminating engineering was referred to by Mr. G. N. Stickney in a recent article on factory lighting in *The Electrical Review* of New York. Adjoining the works of a leading rifle manufacturer was a 220 yards testing range on which experiments were constantly being made with new models, and it was found to be rarely possible to get satisfactory results on this range with artificial light. On examination the intensity of artificial illumination on the targets proved to be about 6 to 8 foot-candles. This might have been considered ample for many ordinary requirements, but it was not so in this case. The daylight illumination, on the other hand, though naturally varying from day to day, was usually in the neighbourhood of 60 to 70 foot-candles. Eventually an improved system of artificial illumination giving about 30 foot-candles was introduced. This proved entirely satisfactory, and later it was decided to use artificial light always as by so doing, an invariable and steady illumination could be relied upon—a matter of some consequence, as tests on different days ought to be comparable one with another.

The Illuminating Engineering Society.

(Founded in London, 1909.)

First Annual General Meeting.

The Annual General Meeting of the Illuminating Engineering Society was held on Monday, May 23rd, at the house of the Royal Society of Arts, John Street, Adelphi, London, W. **The President,** Prof. Silvanus P. Thompson, D.Sc., F.R.S., being in the chair.

Before proceeding to the business before the meeting **The President** alluded to the great loss sustained by the nation since the last time they had met together. The death of King Edward had united all in a common sorrow. Yet all felt that the beneficient traditions of his reign would be maintained by King George, and that, he like his father, would devote himself unsparingly to the welfare of his people.

The minutes of the previous meeting having been read and confirmed, **The President** next called upon the **Hon. Secretary** to read the names of applicants for membership put forward since the last meeting as follows :—

Mr. C. O. Bond, Mr. G. Robson, Prof. F. K. Richtmyer, Mr. E. F. Spurrel, Mr. E. S. Thornton, Mr. R. W. Weekes.

Subsequently the names of gentlemen submitted for election at the last meeting were again announced by the Hon. Sec., and the President declared them formally elected members of the Society.*

The President then called upon the Hon. Secretary to read in abstract the Report of the Council for the year 1909–10. This Report will be found *in extenso* on p. 379.

The President said there was no need to make much comment upon the report, but he desired to mention specially two matters. First he would like to point out the illustration of the extraordinary degree of interest in the doings of the Society, which was afforded by the co-operation of foreign corresponding members representing different professions in Europe and America.

The second matter to which he wished to refer, was in relation to the paragraph of the Report dealing with the future work of the Editing and Papers Committee. They hoped to have papers which would interest a wide circle of non-technical members—papers which would treat phases of the subject of special general interest. In this way they hoped to enlist as members a great many more of those who were not actively engaged in considering the purely engineering aspects of illumination, such as architects, members of the medical profession, &c.

Mr. J. G. Clark moved the adoption of the report, and emphasized the important work which lay before the Society.

Dr. R. Lessing seconded the motion, and the report was adopted unanimously.

The President then introduced the two following resolutions, which had been passed by the Council, and which were submitted to the meeting for adoption :—

(1) That the first sentence of Article 8 in the Constitution of the Society, which at present reads "The President shall hold office for one year only, but shall, after the lapse of a year, be eligible for re-election" shall be modified as follows :—

The President shall hold office for one year and shall then be eligible for re-election ; but his period of office shall not exceed three successive years.

(2) That Article 25 in the Constitution of the Society, relating to the payment of Subscriptions, should be modified as follows :—

Subscriptions shall be dated quarterly becoming due in the quarter of the year in which the member joins the Society.

Continuing, the President said it was prescribed that the present council should remain in office for three years,

* A list of these names will be found on p. 300 of *The Illuminating Engineer*, Lond., May, 1910.

but provision was also made for the addition of new members from time to time, and it was proposed to add three members, viz., **Dr. W. J. Ettles,** Pathologist of the Royal Eye Hospital, **Mr. A. Stokes,** Chief Outdoor Inspector of the South Metropolitan Gas Co., and **Mr. A. H. Seabrook**, Chief Engineer to the Marylebone Borough Council Electricity Department.

In moving the first of these resolutions **Mr. R. I. Wallis Jones** alluded to the very great honour enjoyed by the Society in Prof. S. P. Thompson having consented to act as their President a second time. The great success of the Society was very largely due to his efforts—efforts which had been generously put forth in spite of his being a very busy man. He thought the Council had acted wisely in altering the Articles of Association, and concluded by expressing a hope that Dr. Thompson would be their President for yet a third year. The resolution was seconded by **Dr. A. Levy** and adopted unanimously.

The re-election of Prof. Thompson as President for the ensuing session having been carried with acclamation, **Mr. R. I. Wallis Jones** also proposed a vote of thanks to the President for his services during the past session, which was seconded by **Mr. J. F. Cox,** and was also carried unanimously.

The President thanked the members for having referred in such kind terms to his efforts, and for having re-elected him for a second period of office. He would be only too happy to do all that he could to further its interests, even should he not find it possible to devote quite as much time to the affairs of the Society as he had done in the past, whilst the Society was in its first stages.

The Second Resolution was then moved by **Mr. Haydn T. Harrison,** and seconded by **Mr. W. Okey,** and declared carried unanimously.

A vote of thanks to the Council and officers of the Society was then moved by **Mr. O. P. McFarlan,** seconded by **Mr. Palowker.**

The President, in putting this vote to the meeting, referred in complimentary terms to the services rendered by the Hon. Secretary and his Assistant, and asked Mr. L. Gaster to reply on behalf of the Council.

Mr. L. Gaster, *Hon. Sec.*, thanked the President and the members for the kind manner in which they referred to his services, and added that it had been a great pleasure to him to work with such a harmonious Council. The Society could rely upon the Council doing its utmost to further its interests, and secure the success of the movement. It was expected that all members would do what they could to increase still further the influence and membership of the Society.

Before the conclusion of formal business, **The President** referred in terms of regret to the death of **Dr. M. Corsepius,** who was for sometime Professor at Dresden, and later at Cologne. Dr. M. Corsepius was a valued corresponding member of the Illuminating Engineering Society, and had only quite recently made several interesting contributions to its discussions. He had been responsible for a number of well-known researches in connexion with photometry, and had taken a keen interest in the Society.

It was then announced that **Mr. A. Denman Jones** and **Mr. Val. Mackinney** had been appointed Honorary Auditors to the Society.

The President added that, the financial year ending on December 31st, 1910, the accounts would be duly audited previous to the next Annual Meeting, and the balance-sheet would be presented on that occasion.

A resolution was also moved by **Mr. A. H. Seabrook,** seconded by **Mr. J. E. Edgcome,** and carried unanimously, thanking the Royal Society of Arts for the courteous permission to use its rooms for the meetings of the Illuminating Engineering Society and expressing appreciation of its encouragement and support.

The President then called upon Mr. Haydn T. Harrison and Mr. J. S. Dow to describe two new photometric instruments.

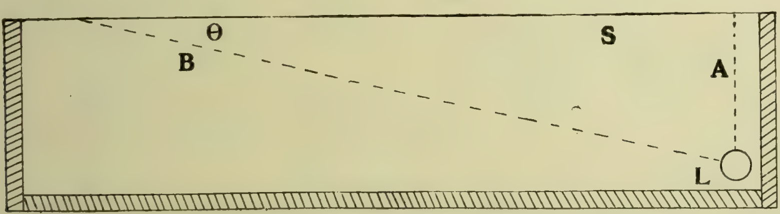
Mr. Haydn T. Harrison then described and demonstrated an instrument which he has lately invented, which he termed an "illuminometer," as

the degree of illumination is indicated on the scale without any adjustment or movement of parts by the operator.

The construction consists of a long, narrow box, the lid of which, when opened, exposes a long, white screen marked with a scale divided into candle-feet. This scale is partly translucent and partly opaque. A standard lamp fixed in one corner of the box is within about 2 in. of the screen and throws its rays directly on it, and over 1 ft. from the other end of the screen, throwing its rays at an angle of only a few degrees from it. This degree of illumination, as seen from the translucent screen varies enormously in the instrument exhibited—from 100 candle-feet to 0.2 candle-feet. By placing the screen at the point where it is desired the apparatus itself, Mr. Harrison was able to demonstrate its use by first laying the instrument on the President's desk. The President was then able to state that the illumination at that point was 1.8 candle-feet. Mr. Harrison then held it against one of the paintings, and the degree of illumination was visible to the members and others collected in the hall, who agreed fairly closely on the reading.

Carrying the instrument round, Mr. Harrison was able to demonstrate the degree of illumination at various points and also that the range of the instrument was such as to make it available for daylight as well as artificial lighting.

Finally, he showed how, by holding it a definite distance, say, 3-.33 ft. from a source of light, it actually



A=Minimum distance of screen from standard lamp say ·1 ft.
B=Maximum ,, ,, ,, ,, 1·1 ft.
θ=Angle of incidence say 7·°, Cos θ=·12
S=Screen.
L=Small glow lamp.

Then, if the C.P. of the standard lamp be unity,

the maximum reading on the scale $= \frac{1}{\cdot 1^2} = \frac{1}{\cdot 01} = 100$ foot-candles.

the minimum ,, ,, ,, $= \frac{1}{1\cdot 1^2} \times \cos\theta = \frac{1}{1\cdot 2} \times \cdot 12 = \cdot 1$ foot-candles.

to ascertain the illumination, it is easily measured by noting the point at which the illumination of the translucent screen blends with that of the opaque part of the screen as illuminated by the external source.

Mr. Harrison, in his remarks, mentioned that the President having stated at a previous meeting that a simple instrument of this description was urgently needed, had set him thinking of how it could be easily and cheaply constructed, which resulted in the instrument he exhibited at the meeting.

The battery supplying current to the standard cell being a small pocket accumulator connected by flexible to indicated the candle-power of the source.

Mr. Harrison concluded his remarks by marking on the blackboard the adjacent diagram, which graphically shows the means by which the large range is obtainable.

Mr. J. S. Dow said that the instrument he was going to show had been devised by himself and Mr. V. H. Mackinney with a view to studying the surface - brightness or intrinsic brilliancy of illuminated surfaces. He wished to express his indebtedness to the kindness of Mr. Konrad Beck, who had put together this model at extremely short notice. He

thought, however, that the principle, which was somewhat novel, would be found of some interest.

The idea of the instrument is to enable an observer to measure the surface-brightness of any surface by comparing it direct with a standard illuminated white one. The manner in which this is done will be understood from the diagram (see Fig. 1). The observer, with his eye at E, looks direct at the illuminated surface S and sees, through an aperture therein, the illuminated surface to be studied—for example, a picture, or some object in a shop window. The surface S is illuminated by an opal glass screen at O. Behind this is a small metallic filament glow-lamp at a sufficient distance to render the screen of uniform brilliancy. can gradually reduce the illumination still further by also bringing over the lever B. This exactly resembles A with the exception that there is no ring cut out. In doing so we gradually cut off the illuminated portion of the opal plate still left exposed and reduce the illumination uniformly from 0·1 to 0. The lever B travels on a second scale immediately above that of A, graduated from 0·1 to zero.

In actually using the instrument one would adjust the position of the glow lamp illuminating the opal plate until the brightness of the white surface S (as compared with another similar white surface illuminated by a standard lamp at a specified distance) is, say, exactly, one foot-candle. One would then fix the lamp in this position and

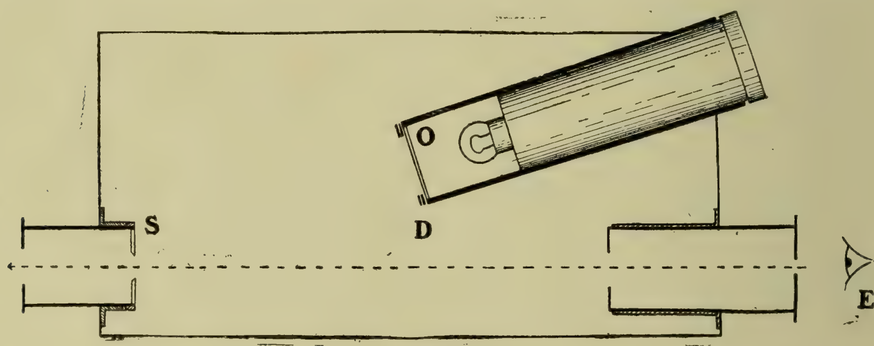


Fig. 1.

regard the scales as registering in foot-candles. It is expected that the range of the instrument will be extended by the use of standard dark glasses in front of the aperture cutting off exactly one-tenth or one-hundredth of the light from the surface studied.

The method of altering the illumination of S is somewhat unusual. The screen S (see Fig. 2) is covered by an opaque diaphragm D, which only allows a sector to be exposed. In front of this evenly illuminated sector two corresponding opaque screens, attached to levers A and B, can be made to pass. As the screen A is moved in front of the sector its area, and therefore its intensity as a light-source will be uniformly diminished from say 1 to 0·1. The remaining intensity, 0·1, is derived from the part of the surface still visible through the ring R. The area of R is arranged to be exactly 1-10th of the total area of the bright sector. The lever attached to A therefore travels on an equally divided circular scale with 9 divisions from 1 to 0·1.

Having drawn across the lever A, we

In an instrument of this kind it is, of course, a distinct advantage to secure a uniformly divided scale. But it need scarcely be added that the principle relied upon involves several assumptions, affecting the uniformity of the brightness of the opal plate, &c., which require to be verified. As far as we have been able to test this matter at present, we have reason to expect that the correctness of the scale will attain the standard desirable in these instruments. Another question that may be raised is the possibility of the reading

being affected by the distance from the eye of the surface examined. Where very large distances are concerned this might well be so, but it appears that under ordinary conditions, involving surfaces distant about 3 to 10 ft. there is no very material difference introduced.

A word or two may be said regarding the units in which the scale ought to be calibrated. Strictly speaking, the instrument measures "surface brightness" or "intrinsic brilliancy." This may be expressed in either of two ways (to which Prof. L. Weber has recently made allusion*), *i.e.*, in terms of "candles per square centimetre" or in terms of the illumination in lux or foot-candles which a truly white surface would have to receive in order to have an equivalent brightness. Were the instrument used to study the intrinsic brilliancy of sources of light and such like brilliant surfaces, the former system might be used, but it is probably less serviceable for specifying the brightness of the illuminated page of a book, or picture, &c., and for most ordinary purposes the latter "secondary" unit is preferable.

Next as regards the use of the instrument. It is clear that its chief distinction from the ordinary photometrical apparatus is that it takes into account a greater number of circumstances. For example, were we to utilise it to study the conditions in a school we should point the instrument at the illuminated book at the same inclination and in the same direction as that in which the child would naturally look when reading. The resulting measurement would give the apparent brightness of the book as seen by the eye of the reader and would depend upon the intensity of illumination, the coefficient of reflection of the material of the page, and the angle at which the book is held. For this reason, while it gives us the actual conditions more closely than an illumination photometer of the usual type would do, it must be used by an observer who clearly understands what he desires to measure and appreciates the number of factors concerned.

An advantage of this instrument is that there is no necessity actually to place the photometer on the spot studied. For example, one can carry this portable apparatus (which is only about 6 × 2 × 3 in.) through the streets and gain information about the lighting of shop-windows by studying the apparent brightness of the goods seen through the windows. We can also examine the contents of glass cases, &c., to which it is inconvenient to get access. One can also very easily and quickly determine the reflecting power of any surface by comparing its brightness with that of a small adjacent

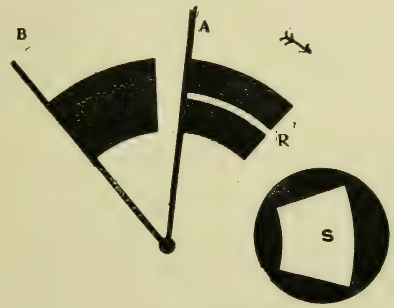


FIG. 2.

piece of white blotting paper or other standard material. It should be specially serviceable for measuring the brightness of luminous signs, advertisements, pictures, notices, and other objects which must be inspected at a distance.

At the same time the instrument can be used as an ordinary illumination-photometer by merely examining the brightness of a standard white surface placed in the locality to be illuminated. The use of a small surface of this kind has several advantages; it can easily be placed in a vertical or horizontal position at any angle, and in corners and inaccessible spots in which a photometrical apparatus, however small and compact, could not readily be placed and observed. Thus one can obtain the intensity of illumination on a vertical bookshelf or inside a box or small recess; this is certainly an

* *Illuminating Engineer*, Vol. III., Feb., 1910, p. 116.

inconvenient thing to do with most of the existing types of instruments.

And lastly it may be hoped that in the future instruments of this class will be found of service in studying the intrinsic brilliancy of sources of light, shades, and reflectors, &c. Certainly the brilliancy of such surfaces far exceeds that of the illuminated objects in an ordinary artificially lighted interior, but the use of a suitable dark glass should enable them to be measured with very fair accuracy.

The President, in commenting on the two types of instruments exhibited remarked that it had been the good fortune of the Society, at each of its meetings, to have some new form of apparatus described. While differing somewhat in their functions from the ordinary photometrical instruments both these pieces of apparatus had their distinctive uses, and their future application would be noted with interest.

The President then announced that the first meeting of the next session would be held on **Tuesday, November 1st**, and that the nature of the proceedings on this occasion would be announced in due course.

The Illuminating Engineering Society.

(Founded in London 1909.)

The Distribution of Energy in the Spectra of Illuminants.

DISCUSSION. (*Communicated.*)

Mr. A. Denman Jones: The paper by Dr. Coblentz published in the last two issues of *The Illuminating Engineer* will be of great interest to the manufacturers of modern illuminants.

So far the most efficient method of using the selective emission of various elements has been by the use of chemicals in the arc of an electric lamp. Calcium is used as a base of most modern chemical arc lamps. This metal will give broad bands in the spectrum in contradistinction to the thin lines given by many elements, notably by iron.

It would be of great interest if Dr. Coblentz could clear up some of the obscure points in connection with selective emission. It is well known that calcium when heated in a Bunsen flame gives a light of brick red colour ; when heated to the higher temperature of the arc this light changes to orange or yellow colour. The law seems nearly universal that a higher temperature produces a light nearer the violet end of the spectrum than is produced by a low temperature even when the emission of light is selective. This appears due more to the lines near the violet end brightening in intensity than to an actual shifting of the lines.

Particularly interesting phenomena are observed when an arc is fed with varying quantities of calcium compounds ; a small amount of calcium will give comparatively narrow bands which are greatly broadened and the light consequently increased as the arc becomes more rich in calcium compounds. The increase in light efficiency is not, however, dependent only upon the amount of calcium salts present. Few commercial chemical arc carbons use a pure calcium compound, it is generally necessary to use other compounds in addition in order to obtain a good efficiency.

Much work has been undertaken in connection with incandescent gas mantles and in these it has been found that neither pure cerium nor pure thorium compounds will give a good efficiency. It is necessary to have a slight percentage of both present. The highest efficiency of chemical arc lamps is obtained in the same way by the addition of small quantities of compounds apart from the calcium, but the reason of this mixture is not at all apparent. Is it possible that some form of chemical combination and dissociation is continually taking place to cause the production of light ?

The Illuminating Engineering Society.

(Founded in London, 1909.)

New Members of Council.

At the Annual General Meeting of the Illuminating Engineering Society, held at the House of the Royal Society of Arts, on May 23rd, 1910, the names of the following three additional Members of the Council were announced:—

Ettles, Dr. W.	Ophthalmic Surgeon, Pathologist to the Royal Eye Hospital, London.
Stokes, A.	Chief Outdoor Inspector of the South Metropolitan Gas Company.
Seabrook, A. H.	General Manager of the Borough of St. Marylebone Electric Supply.

New Members of the Society.

The names of the applicants for membership, read out at the previous meeting on April 14th, were formally announced for the second time, and these gentlemen were declared Members of the Illuminating Engineering Society.*

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the Meeting of the Society on May 23rd, 1910:—

Bond, C. O.	Manager of the United Gas Improvement Co., Photometrical Laboratory, Philadelphia, U.S.A.
Robson, G.	Managing Director of "Auto" Lighter, Ltd., Albion House, 59–61, New Oxford Street, London, W.
Richtmyer, Prof. F. K.	Instructor of Physics, Cornell University, 108, Linden Avenue, Ithaca, N.Y., U.S.A.
Spurrel, E. F.	Borough Surveyor of Holborn, London, E.C.
Thornton, E. S.	Director of Messrs. W. Sugg & Co., Vincent Works, Regency Street, London, S.W.
Weekes, R. W. *M.I.E.E.*	Consulting Engineer, Maxwell House, Arundel Street, Strand, London, W.C.

Corresponding Member

A. Besso (Berne, Switzerland.)

* A list of these names will be found on p. 300 of *The Illuminating Engineer*, Lond., May, 1910.

Obituary.

Dr. M. Corsepius.

It is with sincere regret that we record the death of Dr. M. Corsepius, at the early age of 45 years, on Sunday, May 10th.

Dr. M. Corsepius, as Professor at the Technical Engineering Schools of Cologne, had a deserved reputation for his work in connexion with electrical engineering and his researches on photometry, especially in connexion with the use of the Ulbricht sphere, were known and valued in this country as well as in Germany.

He had, indeed, always taken a keen interest in questions connected with lighting, and had given his actual support to the Illuminating Engineering Society, of which he was a distinguished corresponding member, and to the discussions of which he had already made frequent and valuable contributions.

Members of the Illuminating Engineering Society and all those interested in the progress of illuminating engineering will join in this expression of regret and in tendering their respectful sympathy with his relatives.

Mr. Alfred Colson.

Our readers will also learn with regret of the death of Mr. A. Colson, Chief Engineer and Manager of the Leicester Corporation Gas and Electricity Department, who was also a member of the Illuminating Engineering Society.

Holding as he did a responsible position in connexion with a combined gas and electricity undertaking, Mr. Colson naturally sympathized with a movement for the benefit of illumination in its broadest sense. By his successful administration of the engineering and business departments of his work Mr. Colson won general esteem and was well known and respected both in the electrical engineering and gas industries.

The Illuminating Engineering Society.

(Founded in London, 1909).

Report of the Council for the Session 1909-10.

(Presented at the First Annual General Meeting of the Society, held at the Royal Society of Arts, John Street, Adelphi, W.C., on Monday, May 23rd, 1910.)

INTRODUCTORY.

This report marks the termination of the work of the first session of the Illuminating Engineering Society. The aims and objects of the Society have already been summarized in the address delivered by the President at the inaugural meeting on November 18th, 1909, and in the Report of the Council presented on that occasion.*

Briefly, it may here be recalled that the main object of the Society is the provision of an international and impartial platform where all problems relating to illuminating engineering can be discussed. The Society was created in order to bring together engineers, architects, members of the medical profession, and others, who are interested in various aspects of lighting, so that they might exchange views and help to bring about better conditions of illumination. No organization with this aim had previously existed in this country; and so novel was the idea, when originally presented, that there were some who doubted the possibility of bringing together the different experts in this way. Yet this has been carried out most successfully. There were originally a few who objected to the formation of the Illuminating Engineering Society, deterred by a presumed difficulty in finding sufficient material for discussion or in securing friendly co-operation between those interested in rival illuminants. Those responsible for the movement, however, felt convinced that these difficulties would melt away when once the Society came into existence.

The Illuminating Engineering Society having now completed its first session, it may be said at once that the anticipations of the Council have been fully realized. Although the membership of the Society is of a widely representative character, the periodical meetings, both of the Society and of the Council, have been of an entirely amicable nature. At the same time, the Society has been confronted not by any difficulty in finding matter to discuss, but by the impossibility of doing justice to even small sections of the subject in the time at their disposal. The matters so far discussed have proved to be far too rich in suggestion to be completely disposed of in a single meeting or even a single session; and the Society has already before it a vista of useful work to be accomplished in the course of the next few years.

There has been on all sides a steady growth of interest in questions of lighting, and the Council, in its report of 1909, laid stress on the number of occasional articles dealing with illumination which sporadically appeared in the various scientific and technical journals. Since that date it has been gratifying to observe that a number of lectures and papers dealing with various aspects of lighting have been delivered before different technical societies, such as the Institutions of Electrical Engineers and the various Gas Associations, the Society of Architects, the Association of Foremen Engineers and Draughtsmen, &c.; these invariably gave rise to keen discussions. Special reference may be made to the series of lectures on illumination recently delivered by the President of the Illuminating Engineering Society before the Royal Institution, and to the Christmas lectures of Mr.

* *Illuminating Engineer*, London, December, 1909, pp. 813, 825.

W. Duddell in the same Institution. Even in the learned societies devoted mainly to special scientific matters, the subject of illumination receives important recognition.

The meetings of the Society now receive widespread and regular notice in the press. And, what is equally gratifying, the fundamental ideas in which the society is interested have spread in all directions, so that it is to-day almost impossible to take up a technical journal without finding some aspect of the question of illumination discussed.

Development in street lighting has been much to the fore. Throughout the country public interest in this question seems to have been aroused, and a higher standard of illumination will undoubtedly be demanded in the future.

As the public interest in these matters becomes keener, and a knowledge of the requirements of good illumination becomes more widely extended, the importance of weighing carefully the merits of the different systems of illumination, and the value of impartial expert opinion will doubtless come to be more fully appreciated.

It may also be mentioned that the Committee on Photometry of the Verband Deutscher Elektrotechniker, in Germany, has just issued a series of tentative recommendations regarding the measurement of illumination in open places and in interiors. These recommendations form an important precedent and a basis of working. They have now been submitted to the Deutscher Verein von Gas und Wasserfachmännern with a view to common agreement. This again affords an illustration of the growing desire, on the part of gas and electrical engineers, for agreement on some common basis in the measurement of light and illumination —an agreement which the Illuminating Engineering Society should do much to foster in this country.

Another tendency that is observable at the present time is the inclination on the part of contractors and gas and electrical supply companies to take more interest than formerly in the actual conditions of illumination enjoyed by the consumer, and to give advice as to the best arrangements of his lights. The measurement of illumination will doubtless play a most important part in schemes of lighting in the future and the payment for electricity on the basis of illumination supplied is now coming to be regarded as no mere visionary prospect. The Illuminating Engineering Society, therefore, acting as a centre of information on these matters, welcomes the co-operation of all those engaged in the supply of illumination to the general public.

It may also be noted that the most recently issued reports of the Medical Officer of the Education Department of the London County Council and of the Factory Department of the Home Office contain an increasing number of references to the need for good illumination in schools and workshops. Here again we see the recognition gaining ground that illumination, like good sanitary conditions, water supply, and ventilation, is a hygienic necessity and not a luxury. Our Society is anxious to provide opportunities for the discussion of such questions, and to bring together those interested in lighting appliances and those concerned with the maintenance of good hygienic illumination.

The desirability of better educational facilities in connexion with photometry and illumination at technical institutions and colleges has also been much discussed. At the meetings of the Society the general opinion has been that the present arrangements leave much to be desired. We understand, however, that a movement is on foot to secure an improvement in this respect, and that a commencement in the direction of organizing lectures on the subject will be made shortly.

INCREASED MEMBERSHIP AND SUPPORT.

During the few months which have elapsed since the Inaugural Meeting the influence and membership of the Society has been steadily extended. The number of members which at the end of November, 1909, was about 150, now exceeds 220.

Even more satisfactory than this numerical increase is the fact that the Society has been able to secure the co-operation of many leaders in different professions and in different countries. Indeed, it may be questioned whether any Society has existed which, at so early a stage, could show among its members such a full complement of authorities on the various aspects of the subject with which it proposes to deal.

It is also satisfactory to note that the representative nature of the membership has been fully maintained, that the different systems of lighting are well represented, and that members of the medical profession have shown their interest by coming forward and participating in the debates of the Society. There still remains one quarter in which further representation is specially desired, namely the Architectural and allied professions. Also the gas industry is not as fully represented as is desirable, but it is anticipated that there will be an improvement in these respects as the work of the Society comes to be more fully appreciated and understood.

The distribution of members is proportionally as follows, though naturally this can only be regarded as a very approximate classification :—

	Per cent.
Electrical Engineers and members concerned mainly with Electric Lighting	39
Gas Engineers, Manufacturers of Gas Appliances, &c. ..	18
Professors of Physics, Experts in Photometry, &c. ..	10
Representatives of Oil, Acetylene, Petrol Air Gas Lighting, &c.	8
Physicians, Oculists, Opticians, &c.	8
Architects, Surveyors, &c. ..	3
Miscellaneous, including makers of Shades and Reflectors, Mechanical Engineers, and others not exclusively connected with any one system of lighting	14
	100

Honorary Members.

In accordance with the Constitution of the Society*, the Council are empowered to nominate each year as Honorary Life Members three individuals distinguished for services in connexion with illumination. They are pleased to report that the following gentlemen have been approached and have kindly consented to become the first three Honorary Members of the Society :—

Sir Wm. Preece, K.C.B., F.R.S., Past President of the Institutions of Civil and Electrical Engineers, &c.

In recognition of valuable pioneering work in connexion with the measurement of illumination.

Sir Joseph Swan, M.A., D.Sc., F.R.S. Past President of the Institution of Electrical Engineers, &c.

In recognition of valuable services in connexion with electric lighting and as one of the inventors of the electrical incandescent lamp.

Prof. A. G. Vernon Harcourt, M.A., F.R.S., Past President of the Chemical Society, Metropolitan Gas Referee, &c.

In recognition of valuable services in connexion with photometry and the invention of the standards of light.

Mr. W. M. Mordey, Past President of the Institution of Electrical Engineers, Prof. O. Lummer, the co-inventor of the Lummer-Brodhun Photometer, of Breslau University, and Prof. Violle, the inventor of the Violle Standard of Light, have also consented to act as Vice-Presidents.

THE INTERNATIONAL ATTITUDE OF THE SOCIETY.

In framing the Constitution of the Society special attention was paid to the provision of international intercourse on matters in connexion with illumination. The recent practical agreement between Great Britain, France, and the United States regarding the International Unit of light may serve as an illustration of the kind of work our Society might encourage and help to bring about. It is hoped that in the

* See Articles 5, 18, and 24, *Illuminating Engineer*, Vol. II., 1909, pp. 377, 378.

future many of the terms used in connexion with illumination will become standardized, and that general agreement between the different countries will be arrived at regarding essential points in the measurement of light and illumination. Recognizing the benefit of exchange of opinion on such points as these, the Society has extended the list of authorities in Europe and America, who are acting as its corresponding members.

The assistance of our American and Continental supporters has been much appreciated, and corresponding members have come forward in a most encouraging manner in response to invitations to take part in discussions of the Society. Their communications were read in abstract at the meetings of the Society, and subsequently incorporated in the full published account of the discussions, forming very valuable additions thereto.

It is hoped that in the course of the next few years, as the Society becomes yet more firmly established, the possibilities of international co-operation may be further increased. It is anticipated, for example, that international Congresses, at which the most recent developments in connexion with lighting can be exhibited and the most vital questions of the day discussed, will form a feature of the work of the Society; also that International Committees will be appointed to deal with intricate questions in connection with nomenclature, &c., on which there is at present a lack of satisfactory agreement. A step in this last direction has already been taken by the decision of the Society to form an international committee to deal with the question of "glare" in the use of illuminants.

It may also be mentioned that the Society has been officially invited to be represented at the International Medical Congress to be held in Brussels during September of the present year, and has resolved to send several delegates. It is anticipated that the work of this Congress will be of special interest to our Society since it is the first occasion on which the medical and hygienic aspects of factory lighting, as they affect the health of employees, &c., will be studied in connexion with the engineering aspects of illumination and the use of photometry.

Lastly, the Council would make special reference to the continued progress of the American Illuminating Engineering Society, the pioneering work of which has been of the greatest value to those interested in the formation of a Society with similar aims in this country, and who have now achieved a still steadily growing membership exceeding 1,000. We may hope that our experience will be similar to that of our friends in the United States. It need not be said that we welcome possibilities of co-operation, and it is gratifying to record that, shortly after the Third Annual Convention held in New York last year, the American Society formally passed a resolution wishing prosperity to our efforts and expressing the desire that both societies might co-operate for the improvement of conditions of illumination. A Committee in the United States is already considering the standardization of terms in common use in connexion with illumination; it is therefore hoped that we, in this country, may be able shortly to participate in this effort to promote common agreement.

MEETINGS OF THE SOCIETY DURING THE PAST YEAR.

During the past year five monthly meetings have been held. The Inaugural Meeting took place on November 18th, 1909, and was followed by four discussions in 1910, two of them dealing with 'Glare, its Causes and Effects,' and two with 'The Measurement of Light and Illumination.'

At the Inaugural Meeting the opportunity was taken of setting forth the programme of the Society and showing how its work would be co-ordinated with that of other professions and societies.

A report was presented by the Council summarizing the steps that led to the formation of the Society and the objects which it was intended to perform. An address was also delivered by The President, Prof.

S. P. Thompson, D.Sc., F.R.S., which will doubtless rank as a classic, defining the nature and scope of illuminating engineering. Sir Boverton Redwood, Mr. A. P. Trotter, Prof. J. S. Haldane, Mr. W. M. Mordey, and Dr. R. M. Walmsley, expressed their sympathy with the movement and their conviction of the utility of the work to be carried out by the Society.

The subsequent two meetings of the Society, held on January 11th and February 15th respectively, were given up to a discussion on '**Glare, its Causes and Effects.**' This subject was selected after considerable thought as one likely to appeal to a great variety of experts and to illustrate very clearly the wide scope of the work of the Society. This matter, clearly, is one of consequence to the illuminating engineer. The tendency has been, for some time past, to produce sources of greater and greater concentrated brilliancy; and the question was naturally raised how far objections, on hygienic grounds, to the "glare" of such sources was justified. On this point the experience of the oculist was desirable. The additional questions as to the best methods of screening over-brilliant illuminants, and arranging them so as to avoid glare, demand the attention not only of the experts connected with various methods of lighting, but of architects, and of all those concerned with general problems in illumination. It will be seen, therefore, that this subject was one likely to interest the members of the society as a whole and to appeal to the general public. The expectation that this would be the case was fully justified, as the discussions also attracted much attention outside the Society.

Previous to these meetings a series of questions was prepared and circulated among members and others likely to be interested in the subject. Communications were received in response embodying the views of many corresponding members of the Society. The general opinion was expressed that the question of glare was an urgent one; and that the majority of the modern powerful sources of light of high intrinsic brilliancy, ought not to be exposed in an unscreened state within the direct range of vision. (As explained above, these replies from corresponding members were read in abstract at meetings and afterwards incorporated in the full account of the discussion published in the official organ of the Society.)*

It soon became evident that the subject was of too wide a character to be discussed in a single evening, and it was therefore decided to allot two meetings to this discussion, the first being devoted to the more scientific and physiological aspects of the subject and the second to the more practical applications. Ultimately a resolution was taken that an international committee should be appointed to deal with the various questions raised in greater detail. The discussion was opened by Dr. J. Herbert Parsons, F.R.C.S., and representatives of the Home Office, and the Medical Department of the London County Council, were present, and took part. This discussion was the means of interesting a number of oculists and members of the medical profession in the work of the Society, some of them subsequently becoming members.

The next two meetings of the Society, held on March 15th and April 14th, respectively, were given up to a general discussion on '**The Measurement of Light and Illumination.**' Here again it was considered advisable to select a subject which would be of interest to all members of the Society, and would serve to bring home to those outside the need for its existence. The meetings were to a great extent educational. To many it was certainly a revelation to discover that the process of the measurement of light and of illumination was so far advanced. In this case also it was evident that the subject could only be dealt with in a very general manner in the time at the disposal of the Society. The discussions, if somewhat discursive, certainly succeeded in interesting the general public in the work of the Society and in bringing home the importance of measurements of light and illumination in daily

* See *The Illuminating Engineer*, Lond., Vol. III., 1910, February, March, April, and May.

life. A special feature of the two meetings was the description and exhibition of different types of photometers by the inventors, and actual demonstrations of the measurement of light and illumination.

The discussion brought up a number of novel points of considerable interest to experts in this field, while the communications received from corresponding members in the United States and on the Continent were again of special value. The plan adopted previously, of circularizing a series of inquiries before the meeting, was again followed on this occasion, and was productive of useful information.

Many of the chief authorities on photometry and illumination in this country and abroad have already participated in the discussions and given active assistance and support. Among those to whom we are indebted special contributions from the Continent and the United States we may mention, among others, the names of Dr. Louis Bell (Boston), Dr. L. Bloch (Berlin), Prof. A. Blondel (Paris), Dr. M. Corsepius (Cologne), Dr. E. P. Hyde (Ohio), Dr. Hugo Krüss (Hamburg), M. Lauriol (Paris), Dr. Lux (Berlin), Prof. Rumi (Genoa), Dr. Clayton Sharp (New York), Dr. Karl Stockhausen (Dresden), Prof. H. Strache (Vienna), Prof. Dr. R. Ulbricht (Dresden), Prof. L. Weber (Kiel), &c.

THE FIRST ANNIVERSARY DINNER OF THE SOCIETY.

The first anniversary dinner of the Society was held on February 10th, 1910. The occasion presented an opportunity of demonstrating the many points of common interest with kindred Societies and of expressing the desire for co-operation in matters connected with illumination. The dinner proved to be most successful and enjoyable, and a number of influential representatives of other Societies were present. In the unavoidable absence of the President, the chair was taken by Sir Henry Trueman Wood, one of the Vice-Presidents of the Illuminating Engineering Society and the Secretary of the Royal Society of Arts, to whom the thanks of the Society are due for kindly presiding at such short notice. In the course of the evening the toasts of "The Prosperity of the Illuminating Engineering Society," "Our Honorary Members" "Kindred Societies," and "Our Guests," were proposed by Mr. A. P. Trotter, The Chairman, Mr. L. Gaster, and Col. W. F. Leese, and responded to by Prof. A. G. Vernon Harcourt (Hon. Member of the Illuminating Engineering Society), Mr. J. W. Helps (President of the Institution of Gas Engineers), Mr. W. M. Mordey (Past President of the Institution of Electrical Engineers), Prof. A. D. Waller (Treasurer of the Physiological Society), Col. Lane Notter (the Royal Sanitary Institute), Dr. T. M. Legge (Medical Inspector of the Factory Department of the Home Office), Mr. W. Finlay (President of the Electrical Contractors' Association), Mr. W. J. A. Butterfield (Secretary to the Metropolitan Gas Referees), &c.

The Hon. Secretary, in proposing the toast of "Kindred Societies," stated that co-operation was the keynote of the policy of the Illuminating Engineering Society, and that the assistance of older Societies was cordially desired and welcomed: "No one individual to-day—no society even—can claim a monopoly of knowledge." But it was pointed out that a society having among its members authorities on all the different aspects of the subject could, by their united efforts, gather information in a way in which no individual could do. The speakers on behalf of the various societies represented expressed their sympathy with the movement and their conviction of the need for the Illuminating Engineering Society, which had much useful work before it.

FUTURE WORK AND PROCEEDINGS FOR THE NEXT SESSION.

The general policy of the Society and the possible line of work which it may be expected to undertake in the near future will be understood from what has been said above, and it should not be necessary to do more than briefly recapitulate a few of its intentions. It has been shown in the past session that the ground to be covered

by papers is extremely wide. There is not the least difficulty in finding subjects for discussion, and the Editing and Papers Committee is arranging for the regular contribution of papers by individual readers upon selected topics.

In the forthcoming session it is proposed to follow up the policy of devoting the monthly meetings to subjects which will directly interest the general body of members. For example, it is contemplated that papers on such questions as **the lighting of streets, shops, libraries, schools,** &c., will be presented. In this way it is hoped that the Society will succeed in gaining influential support in many quarters in which it is desired to kindle interest and to extend still further its circle of sympathizers.

There are also matters of more purely technical interest to be dealt with, such as **units, nomenclature, standardized conditions of testing,** &c. Meantime it has been suggested to the Council that, for the benefit of those interested mainly in these purely technical aspects of the subject, supplementary meetings should be held between the regular monthly meetings of the Society so that members can meet and discuss these special questions. The Society is also considering the organization of **courses of instruction** upon **illumination and photometry.**

APPEAL TO MEMBERS.

The Council, while conscious of the exceptional and generous support it has so far received, desires to impress upon the members the importance of doing their utmost during the vacation to interest others in the work of the Society, in order that the second session of the Society may be begun with even greater certainty of success than its first.

By Order of the Council,

LEON GASTER, *Hon. Sec.*

The Measurement of Light and Illumination.

DISCUSSION. (*Communicated.*)

(*Continued from p. 322.*)

Mr. G. F. Boxall (Great Western Railway).—The measurement of illumination in the Electrical Engineers Department of the Great Western Railway has up to the present been confined to three sets of conditions, viz., platform lighting, yard lighting, and train lighting. No attempt has yet been made to obtain systematic measurements of interior lighting other than train lighting, as special conditions are met with in nearly every case which would render comparative results of doubtful utility. The main difference lies, of course, in the fact that the problem of outdoor and platform lighting is to provide as good a general illumination as possible, whilst in rooms and offices it has been the aim rather to concentrate the light at particular points. It is possible, however, that this latter aim is quite wrong. Electric train lighting in general combines both these conditions, with the added condition of a reduction of the light to such a small value as to render sleeping easy without putting the compartment in complete darkness. In estimating the efficiency of the lighting of any area when a general illumination is required, the minimum illumination is recognized as being the most important thing to consider, and as in the case of yard lighting, a minimum on a horizontal plane of 0·02 foot-candles may be quite satisfactory, while the maximum may very well amount to 2 foot-candles, the demand made upon the capacity of the photometer is at once apparent. All measurements have been made with the Trotter illumination photometer, with the screen horizontal and 4 ft. from the ground. The tripod has a triangular shelf which is bolted on in a fixed position inside the legs and serves to carry the battery as well as to ensure that the height of the photometer is always correct. The arrangement described has been used on rough ballast, and among points and crossovers on the railway, without any

particular difficulty as regards levelling. A spirit level is essential under these conditions, but even then it is generally possible to obtain thirty readings in half-an-hour. On platforms this rate of working may be greatly exceeded, and from four to six readings a minute can easily be obtained on platforms lit by glow-lamps. Arc lamps have an unfortunate habit of feeding at the critical moment, which sometimes necessitates a good deal of delay, and gives rise to illumination curves of curious shape. Flame arc lamps are the worst offenders in this respect, and some of them almost defy measurement. It appears to be the practice of lampmakers when measuring the illumination from their lamps to wait for the peaks, but curves obtained in this way are of little value to the user of the lamps, and it would be quite as logical for the user only to measure the depressions for purposes of comparison with other lamps. The practice in these cases is for the observer to follow as best he can the variations in the illumination, and for a second observer to watch the movement of the pointer and decide upon a fair average value for the reading. The very rapid and smooth working adjustment of the Trotter photometer makes this easier than might appear at first sight.

With regard to the colour difficulty, the tinted screens supplied with the photometer have never been used, partly because the "constant" for the screen introduces an element of uncertainty, and chiefly because it is quite easy to work without them in all the cases which have been dealt with so far.

Before starting work the photometer is always checked by a standard lamp, and after working all night and taking more than three hundred readings, using the ordinary 4-volt 20-amp.-hour "ignition rate" cell a recheck has shown no appreciable error.

Where measurements are being made in a line between two lamps and no side lighting affects the readings, it appears that it is only necessary to be particular about the levelling of the screen in the direction along the line of measurement; at right angles to this line, a tilt of the screen will only affect the readings proportionately to the cosine of the angle which the plane of the screen in this direction makes with the horizon and an error of a few degrees will have no appreciable effect.

Mr. J. S. Dow:—

With reference to Mr. Cooper's comment on the detail-revealing powers of red and blue light* it is, of course, not easy for every one to form even an approximate judgment as to the relative brightness of such colours as these. It is, however, possible to arrange so that the red is unmistakably the darker to the eye, and yet the detail illuminated by it is most distinct; obviously, too, if the eye cannot focus light of a certain colour no increase in light will enable one to see properly. The possibility that the greater distinctness of the red might be due to the fact that printer's ink reflects less light of this kind less well than blue is negatived by the fact that when the eye is close up one usually cannot perceive much difference; it is only when one gets, say 10 or 20 ft. away that the "shortsightedness" for blue light becomes apparent. This effect was demonstrated many years ago by the late Dr. Shelford Bidwell.

* *Illuminating Engineer*, London, Vol. III.' 1910, May, p. 321.

A CORRECTION.

Our attention has been drawn to an error in the translation of the remarks of Dr. M. Corsepius occurring on p. 316 in our last number. The sense of the sentence commencing on the 18th line of this contribution has been inverted.

The correct version is :—

"Were the mean spherical candle-power adopted as the basis of comparison the apparent *specific consumption* of arclamps might often be doubled, while that of glowlamps would only be raised about 25 per cent.; that is to say, the glowlamps, according to existing system of rating, appear *worse* than they really are."

The Illuminating Engineering Society.

(Founded in London, 1909.)

The Direct Measurement of the Total Light Emitted from a Lamp.

DISCUSSION. (*Communicated.*)

(*Continued from p. 323.*)

Professor R. Ulbricht (Dresden).—I should like to make a few remarks on the paper by Dr. W. E. Sumpner which you have kindly submitted to me for comment. Dr. Sumpner appears to recognize the value of the Globe photometer as a means of measuring the mean spherical candle-power of a source, but contends that, on account of various disturbing factors, the actual behaviour of the apparatus is not in accordance with theoretical considerations. He proposes to achieve greater simplicity by departing from the spherical shape and adopting a cubical box. Among the sources of error in connexion with the Globe photometer he mentions :—the possible want of uniformity in the reflecting power of the inner coating of the globe for light of different colours; the effect of "foreign bodies" inside the sphere; the fact that pure diffuse reflection from the inner coating may not be practically possible; and, finally, the possibility that the milky glass screen let into the observation window does not completely diffuse the light falling upon it.

To these criticisms I reply that the choice of a suitable material for the inner coating is naturally of considerable importance, and Dr. Sumpner is quite right in asserting the disturbing influence of any distinct colouration. Nevertheless, we have at our disposal materials which can be used for a long time without showing any appreciable change in uniformity or in selective reflecting power for different qualities of light. The requisite high diffused reflecting power is also obtainable without any difficulty, but it may be added that the numberless successive reflections which the light undergoes inside the globe renders moderate deviations from the Cosine Law of very little consequence in practice.

The possible error due to foreign bodies in the globe, such as screens, &c., as I have previously shown,* need exert very little influence of practical results, in globes of the prescribed dimensions.

As regards the milky glass in the observation window it may be remarked that if a suitable choice of glass, obscured in the *inner* side, is made, any deviation from the complete diffusion of light would give rise to only very trifling errors. Moreover, such errors are much less considerable in the case of a globe photometer than those which would occur in the case of such a surface illuminated from behind by a source of comparatively small dimensions; in the case of the globe the source of light is a very extensive illuminated surface and any alterations are eliminated. However, the use of a milky glass screen is by no means essential to the principle of the globe photometer, and it is possible to utilize the direct radiation from a portion of the inner surface opposite the opening in the globe. This method has been found both simple and serviceable.

On the other hand, by forsaking the spherical form, as Dr. Sumpner suggests, very considerable sources of error may be introduced, the magnitude of which depends on the extent of

* Uber die Vorgänge im Kugelphotometer, *E.T.Z.*, 1905, p. 512.

the deviation in shape. In order to realize this we need only consider the conditions under which the light is reflected in a box of cubical form. It is obvious that the portions of the surface in the corners, being more remote than those at the middle of the sides of the box, will receive less light, and the reflection therefrom, will be correspondingly affected. One result of this is that the results of using such a box would be very materially influenced by the position of the observation window. Such deviations from the true value would increase with the coefficient of absorption of the walls and with an absorption coefficient in the neighbourhood of 20 per cent. (as may occur in practice), ought certainly not to be neglected. In the case of unsymmetrical sources of light, calculation shows that discrepancies of as much as 40 per cent occur.

The form of enclosure suggested by Dr. Sumpner can, in any case, only give fairly correct results in the case of sources having an approximately uniform polar curve of light distribution, and placed symmetrically with respect to its surroundings. These conditions are the exception in actual practice. On the other hand, theoretical considerations show that the sphere, *and the sphere only*, gives results independent on the polar curve of light distribution or the position of the source of light.

It is, therefore, difficult to understand why it should be suggested that the spherical form, which is theoretically correct, and which has been repeatedly tested in actual practice, should be superseded by a box of a cubical or other non-spherical shape.

I have, however, noted with great interest the publication of Dr. Sumpner in *The Philosophical Magazine* for 1893, in which he discusses the use of a hollow globe with a diffused reflecting inner surface. This paper was previously unknown to me, but it might naturally have been expected that the properties of a hollow sphere of this kind would not have escaped notice at the hands of several experimenters.

Dr. L. Bloch, Berlin—As appears from the contribution of Dr. W. E. Sumpner, and from the discussion published in the last number of *The Illuminating Engineer*, the use of the Ulbricht globe is now attracting much attention in England as a means of determining mean spherical candle-power. We, in Germany, have made extensive use of this apparatus during the last five years, and to-day there are probably not many laboratories in existence in which tests of arc-lamps are carried out, where the Ulbricht globe is not employed. In many quarters there is already a disposition to prescribe that measurements of arc-lamps should be exclusively carried out by the aid of this instrument. The apparatus has also proved serviceable for tests of glow-lamps, though the globe has been comparatively little used for lamps of this kind owing to the fact that it is mainly the mean horizontal candle-power that is usually determined, and specified. Experiments have been in progress for some time with the object of determining whether the globe can be satisfactorily employed for the testing of gas lamps without the access of air to the burner being injuriously affected, and we hope to hear further particulars on this point very shortly.

Dr. Sumpner's paper seems to me liable to create impressions regarding the Ulbricht globe which are not borne out by our experience, and I should therefore like to enter into a few of the objections raised. That the colour of the interior of the globe ought to be of a pure white, and that no intermixture of other tints should be permitted is obvious. But the preparation of suitable permanent coatings of this nature presents no difficulty, especially when little or no adhesive material is added. There is also no difficulty in securing a surface which reflects in a diffused manner and is not shiny. It is, of course, unquestionably necessary that the coefficient of reflection of the interior of the globe should be high and uniform. Yet a globe utilizing a surface of comparatively poor reflecting power may yield quite correct results, provided that all direct light is screened from the observation window. It even presents a certain advantage, namely that the

constant of the apparatus is not so liable to alter in the course of a year, owing to a gradual deepening in tint of the reflecting material. The influence of foreign objects inside the globe, such as the screen and the accessories of the arc lamp tested have been proved, according to the researches of Ulbricht and others, to exert but a slight and usually negligible influence on the exactitude of measurements, provided the sphere has a diameter of at least 1 metre, and the foreign bodies within have not an exceedingly large area. Moreover, the effect of any such bodies can be completely eliminated by determining the constant of the apparatus, with the foreign bodies in position, just as they are during the test.

Dr. Sumpner lays most stress on the suggestion that the glass screen covering the observation window should transmit only diffused light and not direct rays. I can perceive in this no special defect peculiar to the Globe photometer. In any case this objection might be equally well raised against many forms of photometers and photometrical apparatus. Whether a plate transmits mainly direct or diffused light can, however, be very readily determined; for example, by holding the plate in front of a glow lamp and observing whether the shape of the filament is still visible. Moreover, one can dispense entirely with the use of a glass plate over the observation window if one uses a suitable type of portable photometer directly attached to the globe itself, as described by the author in this journal.*

It was very interesting to me to perceive from Dr. Sumpner's paper that he, as far back as 1892, had demonstrated the existence of a principle which is the exact basis of the Ulbricht globe photometer. It is only surprising to me that after obtaining this result Dr. Sumpner did not proceed to construct a globe as a measuring instrument, especially in view of the fact that he himself had previously experienced the want of a satisfactory apparatus for determining the mean spherical candle-power. Dr. Sumpner's method (described on p. 233 of the April number of *The Illuminating Engineer*), involving the use of the graduated paper strip for deterimining the total amount of light from an arc-lamp, can only be regarded as a very inefficient substitute for the theoretically correct and practically very convenient and simple Ulbricht globe.

The apparatus now described by Dr. Sumpner in his subsequent communication, is also, in my opinion unsatisfactory. The theorem established by Dr. Sumpner himself in 1892 is exclusively true for a spherical surface and not for others, such as the cubical box which he now proposes. In such a piece of apparatus the illumination of the observation window by reflected light would always depend upon the nature of the distribution of the rays from the source and its position in the interior instead of solely upon its mean spherical candle-power as is the case for the Ulbricht globe. Even less satisfactory results might be anticipated from the use of this apparatus if the interior was not matt white, but enamelled with some shiny material. Dr. Sumpner even advocates dispensing with a screen and leaving the observation window open so that the opposite face of the box is seen through it. Such an apparatus could, according to my experience, only yield very unreliable results and could only be applied for the direct comparison of lamps of the same kind having similar curves of light distribution. Equally incorrect, theoretically, is the further proposal of Dr. Sumpner to render one eighth of the surface transparent and diffusive, and to measure the transmitted light. The projection of this light by means of a mirror arrangement inserted into the photometer also appears both a less simple and a more expensive device than the Ulbricht globe.

On all grounds, therefore, Dr. Sumpner's proposed apparatus seems to me to present no advantage over that of Ulbricht. The determination of mean spherical or mean hemispherical intensity can be accomplished rapidly and

* *Illuminating Engineer*, Vol. I., 1908, p. 276, and Vol. III., 1910, p. 266, fig. 8.

simply and exactly by means of the Ulbricht globe ; such devices as those referred to above can yield little satisfactory result, and certainly constitute no improvement.

Mr. J. S. Dow (London) :—I do not entirely agree with Dr. Sumpner's criticism of the action of the Ulbricht globe on p. 325 of the last number of *The Illuminating Engineer.* He says "This globe can only give good results if ρ is large, and if the photometer window is perfectly diffusive." It is certainly advantageous for ρ to be large, but Dr. Sumpner seems to me to overestimate somewhat the probable error due to its not being so.

In the first place it seems to be the invariable practice with the Ulbricht globe to s reen the observation window absolutely from the direct rays. The error due to their action should thus be practically eliminated. But even were the window unscreened the error might not be large. Dr. Sumpner shows that, with ρ=90 per cent, I_0, the variable illumination, is only 10 per cent of the part proportional to the total flux of light. Now with a reasonably symmetrical distribution of light from the source I_0 itself should not vary very greatly in different parts of the globe, and, unless very unfavourable conditions were met with, would probably hardly affect the result by more than about 5 per cent.

This is apparently in accordance with the observation of Dr. Bloch that consistent values can be obtained even with a relatively low value for ρ, and also that it is immaterial to the result where the observation-window is placed.

Dr. Sumpner adds that the window must be perfectly diffusive, for otherwise its illumination would be noticeably affected by the portion of the globe immediately opposite it. The brightness of this region, which is not screened from the direct rays, will depend to some extent on I . But it should surely be possible to find a screen sufficiently diffusive to render the amount of light transmitted direct from this portion of the globe relatively small in comparison with that received from the rest of the surface—especially when we remember that, *in a globe*, any bright patch illuminates any other to the same extent. In any case, it would certainly seem to be a much better plan to use a semi-diffusing screen, the brightness of which is at least influenced by light received obliquely from all parts of the sphere, than to dispense with a screen entirely, and merely utilize the light coming direct from a small region of the surface opposite.

This leads me to comment upon an obvious defect in a cubical surface. In such an interior it is very far from being true that any part of the surface is equally effective in illuminating the the observation window. On the contrary it is obvious that the side of the cube in which the window is cut cannot illuminate it at all.

This might not matter much if a source of light having a fairly uniform distribution of light was examined. But if we imagine that the source happens to be so arranged that the great majority of its light is cast upon the side of the cube in which the window is placed, it seems highly probable that the result will be abnormally low. Measurements might then be materially influenced by the position of such a source inside the globe and the location of the observation window.

However, it is conceivable that in practice better results might be obtained than theoretical considerations would suggest, and I hope to be able to give the results of some experiments on this point shortly. There can be no questions that, for a person who has to design and make his own apparatus, a cubical box is a much simpler contrivance than a globe. On the other hand one can imagine that, were the globe a standardized piece of apparatus in very general use, so that there was a demand for considerable number, and were measurements in terms of mean spherical candle-power universally specified, it could be constructed by an instrument maker fairly cheaply and without much trouble.

I should like to know whether Dr. Sumpner has considered mathematically how far the qualities of the cube and the hollow sphere might be expected to approach each other if

both were very large. One would expect that the error involved would be reduced, and that it might therefore sometimes be preferable to partition off a part of the laboratory and make the walls, floor, and ceiling a dead white. In the case of large spaces like this the illumination at the observation window might be low, but this difficulty can be avoided by attaching a suitable photometric screen (a grease spot, for example) at the aperture and looking at this direct. The illumination of the screen would be adjusted by altering the distance of the comparison lamp, and no question as to the inverse square law holding for this illuminated aperture would arise.

Regarding Dr. Sumpner's expressed preference for the use of luminous flux and the lumen it may be said that this term seems to be finding very general acceptation in the United States.

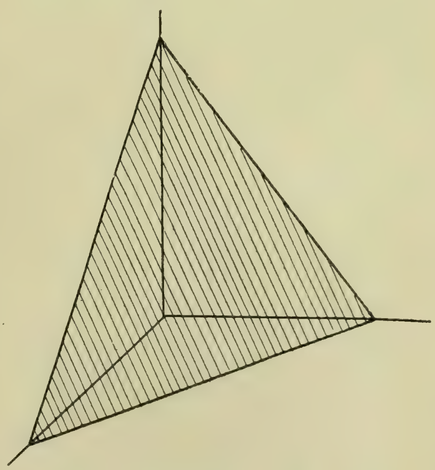
An illustration of the value attached to this method by the Welsbach Co., in the United States, is provided by Mr. N. Macbeth's contribution to this discussion (*Illum. Eng.*, Lond., May, p. 319). It will be seen that the flux in lumens for a given fixture is given not only in the upper and lower hemisphere, but also over a downward angle of 60 degrees.

Prof. G. W. O. Howe: In the current number of *The Illuminating Engineer* I see that Dr. Sumpner has suggested the use of a cubical diffusing chamber in place of the Ulbricht sphere. Three years ago I was thinking of having such a sphere constructed when the idea occurred to me that a cubical chamber would possibly be quite accurate enough for ordinary practical purposes. A box having an edge of 3 ft. was constructed by two students of the Central Technical College and has formed a part of the equipment of the Photometrical Laboratory for the last three years. It is lined with white blotting paper, except at the bottom, where falling pieces of red-hot carbon rendered it necessary to replace the blotting paper by white-washed sheet-iron.

For experimental purposes, one side was pierced by twelve circular openings which could be either plugged up or used as windows. By making measurements successively at each of these twelve windows, the equality of the brightness over the interior surface could be tested. In order to make the conditions as severe as any likely to be met with in practice, the source of light usually employed in our experiments was a 100-candle-power tungsten lamp, blackened over one hemisphere so as to be quite opaque, the other side being left plain. If the box acts perfectly the photometer setting should not alter when the lamp is rotated so as to present first the bright side and then the opaque side to the window. The window is, of course, screened from direct illumination. The screen can be moved so as to shade any one of the twelve openings.

For demonstration purposes in the lecture theatre, the window, covered with tracing cloth, is turned towards the audience and the lamp, blackened on one side is slowly rotated. It is impossible to tell from the appearance of the window which way the lamp is turned.

I have found that it is very necessary to ventilate the box when testing-flame arc-lamps as the fumes may form quite a dense fog, which will entirely vitiate the results.



A very simple way in which the cubical box can be made to approximate much more closely to a sphere is to fit triangular pieces of wood or cardboard

so as to block up the corners, as shown in the sketch. With this improvement I v ry much doubt whether the error introduced by not using the expensive spherical chamber exceeds, or even equals, the errors unavoidably introduced by the screen and the lamp fittings.

In conclusion, I should like to advise all those interested in this subject to read Dr. Sumpner's paper in the *Phil. Mag.* for 1893, in which he makes the meaning of brightness and illumination, transparency and absorption, &c., very clear indeed.

Dr. W. E. Sumpner (*in reply*): I am glad that my suggestions in regard to the measurement of light by diffusion methods have induced Professor Ulbricht and others to make several interesting criticisms. It was no purpose of my article to undervalue the Ulbricht globe, the commercial accuracy of which I fully admitted. I merely raised the question of the possibility of constructing a cheaper form of apparatus working on the same principle. Dr. Bloch, I notice, not only contests the accurate action of the box form of enclosure, but also regards this as "a less simple and more expensive device than the Ulbricht globe." If he can tell me where I can buy a good form of Ulbricht globe at less cost than a white-washed wooden box equipped with a couple of ordinary mirrors, I shall be delighted, and will promise in future to give preference to the globe.

Theories, however, perfect, are always incomplete, and are upset in practical application by the action of unconsidered trifles whose influence can only be judged by actual testing. The Ulbricht globe only acts perfectly when it has nothing inside it. Perfect accuracy is not needed, and is not possible in commercial photometry. If sufficient precision is obtainable with a box form of enclosure, this possesses distinct points in its favour as compared with the globe form. I pointed out four assumptions made in connexion with the theory of the Ulbricht globe; but I at once admitted that two of these were quite justified in practice, and these need not be further discussed. The remaining criticisms relate to the presence of "foreign bodies" and to the action of the diffusing window used with the photometer. On these and other points there appears to be some difference of opinion. I quite accept Prof. Ulbricht's statement that he has shown that foreign bodies need have but negligible effect in globes of suitable dimensions. Dr. Bloch states that all is well if the diameter is as large or larger than one metre. But it does not follow that sufficient precautions are always taken in practice. On page 268 of the present volume of *The Illuminating Engineer* will be found tests by A. A. Perrine, quoted from *The Electrical World*, of New York. These appear to show that the globe may yield results differing by 25 per cent., according to the position of the lights within the globe. In these tests the globe was 1·2 metres in diameter, and the lamps tested were not arcs, but glow-lamps with reflectors. Whatever may be the cause of these discrepancies, I feel confident that if suitable precautions are taken such errors will occur neither with a globe nor with a cubical box.

As regards the diffusing window, Prof. Ulbricht says this is "by no means essential" to the globe photometer, and that it has been "found both simple and serviceable" to utilize the direct radiation from the surface opposite the opening. On the other hand, Dr. Bloch states that such a method would, according to his experience, "only yield very unreliable results." The fact that two such experienced users of the globe photometer differ on such a matter shows conclusively that the operation of the cubical enclosure must be judged from actual testing and not from personal opinions. My main contention is that the accuracy of the results obtained with the globe is due to the high reflecting power of the surface rather than to its spherical form. High reflecting power is fully acknowledged as advantageous by all the critics, but their view is that it is not necessary for accuracy provided the window is screened from direct light. This would be quite true were it not for the presence of "foreign

bodies." The influence of these can be rendered negligible either by increasing the size of the sphere, or by increasing the reflecting power of the surface. The lower the reflecting power, the larger must be the sphere to secure the same accuracy. Unless the value of ρ were high the size of the sphere needed in some cases would be impracticably large. It is only in this sense that a high value of ρ is needed in the case of the sphere. For the cube the same consideration holds good, but a high value of ρ is also important to render negligible the small error due to non-uniform radiation from the lamp.

I cannot accept two statements made by Dr. Bloch. He says that the effect of foreign bodies can be completely eliminated by calibrating the apparatus with the foreign bodies in position. If this were so a globe containing a black screen would yield the same result for a bull's-eye lantern, whether the lantern were arranged to point to the screen, or to point away from it; yet in one case no light at all would be sent to the photometer. Again, Dr. Bloch does not discuss the magnitude of the error due to partial transparency of the diffusing window, but states that any such error is common to many forms of photometer, and he is presumably prepared to disregard it. He implies that a diffusing window, through which the filament of a glow-lamp cannot be distinguished, is sufficiently diffusive for use with the globe. I very much doubt this, for my tests in 1892 proved that such surfaces might still transmit a large percentage of incident light without a shift of direction.

Dr. Bloch is surprised that on noticing in 1892 the special property of the sphere, I did not at once suggest its use for measuring luminous flux. I had the same feeling myself on first hearing of the Ulbricht globe, but the idea was all the same quite new to me. There is a world of difference between noticing a principle, and suggesting a useful application of it. I did at the time usefully apply the principle to the matters in which I was then interested, namely, to the influence of reflection on the illumination of rooms, as affected by the various reflecting powers of different parts of the walls, &c. If I had been considering the measurement of luminous flux, instead of its distribution, I might have thought of the Ulbricht device; but if I had suggested this it would most probably have been in connexion with a cube and not with a globe.

The present discussion has not developed any real criticism of my arguments in reference to the action of a cubical enclosure. Prof. Ulbricht alludes to the smaller direct illumination of the surfaces at the corners. Prof. Howe suggests truncating these corners, and Mr. Dow points out that the flat side containing the window does not directly help to illuminate this window. These points have little bearing on the real issue. With high reflecting surfaces the brightness of the corners will differ very little from that of the other surfaces. The brightest parts illuminate the darkest, and *vice versa* the general influence of diffusion being to produce uniformity of brightness. But accuracy is not really dependent on equality of brightness. All that is wanted is for the brightness of the small patch of surface used by the photometer to be a measure of the luminous flux. If the corners of the box were covered with black velvet it does not follow there would be any error, although, of course, the calibration would be affected. I am much interested to learn from Prof. Howe that the cubical enclosure has been tried at the Central Technical College with satisfactory results, though the tests mentioned are not conclusive on all points. Mr. Dow's suggestion to use a whitened room as the rectangular box is a thoroughly good one, and merits trial.

In conclusion, I have not asserted that there is any error to which the globe photometer is liable which cannot be sufficiently reduced provided reasonable precautions are taken, and I have made no claim for extreme accuracy with the box form of photometer. The actual errors with either form of apparatus cannot really be settled theoretically; they must be experimentally tested.

The Use of Metallic Oxides in Arc Lamp Electrodes.

By Dr. B. Monasch (Augsburg.)

(*Continued from p.* 253.)

II.

An examination of the structure of the arc yields much useful information regarding its value as a producer of light. In the case of pure carbons, it is recognized that only a very small portion, perhaps 5 or 10 per cent, of the total amount of light comes from the arc itself. By far the greater portion comes from the incandescent crater and the tip of the negative carbon. As Mrs. Ayrton has shown, there exists in an arc of this description an inner light-absorbing violet-coloured core which is surrounded by a black band (B in Fig 4). When burning in atmospheric surroundings this black band is again surrounded by a greenish aureole, C. This appearance is characteristic of the carbon arc struck between vertical carbons in the usual way.

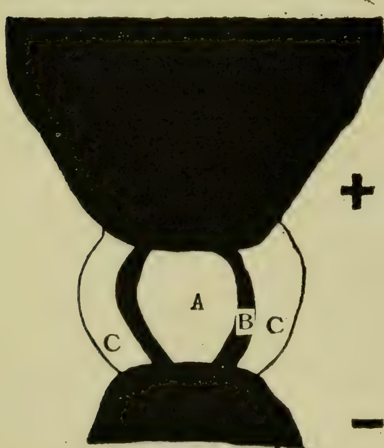


Fig. 4.—Length of Arc 55 mm.
Carbons, Plania Cored, + ve 18 mm. diam.
" " – ve 12 "

In arc-lamps of the ordinary type, using pure carbons in the manner prescribed, the arc is always relatively small in length. Thus in a 20 ampere 44 volt lamp (this is a higher current than would be met with as a rule under practical conditions), the arc is about 4·2 mm. in length. Even when the arc-length is somewhat greater, however, one still recognizes the existence

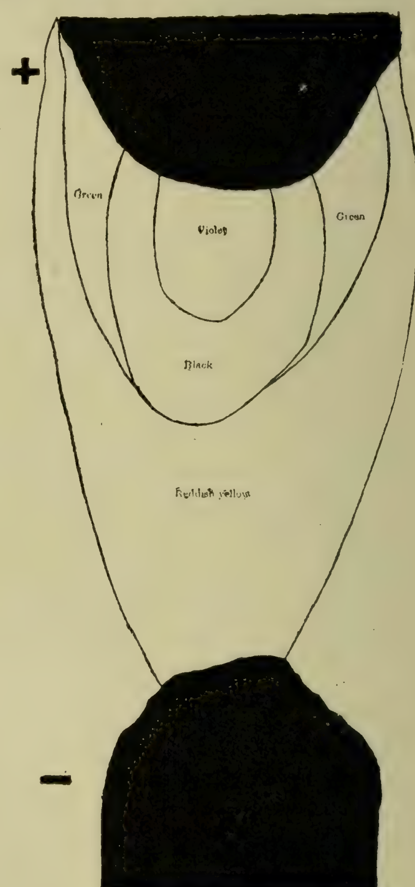


Fig. 5.—Length of Arc, 20·2 mm.
Plania Cored Carbons, + ve 18 mm. diam.
" " – ve 12 "

of the violet, black, and green zones as long as pure carbons are used.

In the case of a long arc between cored carbons, however, the appear-

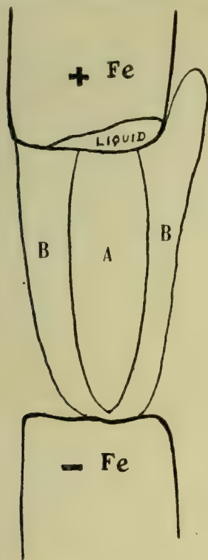


FIG. 6.

ance is essentially different, as will be seen from Fig. 5.

This shows the appearance of a 6 amp. arc struck between "Plania"

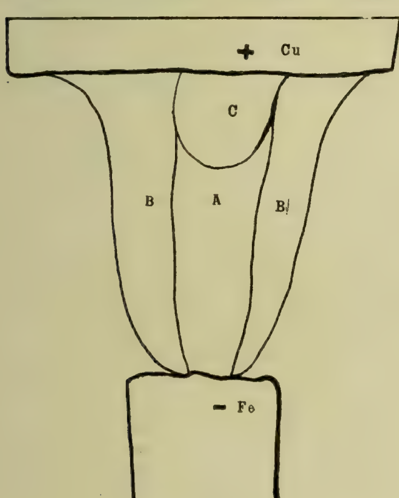


FIG. 7.

cored carbons, the negative and positive carbons being 12 and 18 mm. in length respectively, and the length of arc 20·2 mm. A violet core proceeds from the anode, and is surrounded by a black envelope, which again has a green aureole. But the violet core does not extend from cathode to anode as is the case for a similar length of arc with pure carbons. In this case a reddish yellow flame emerges from the cathode. Its brightness decreases somewhat as we approach the outer surface of the arc.

Fig. 6 represents an arc struck between iron electrodes. This arc, and also those shown in the succeeding illustrations, burns 80 volts with a current of 4 amperes. In this case there is a bright-blue luminous inner core, A, surrounded by a red-yellow

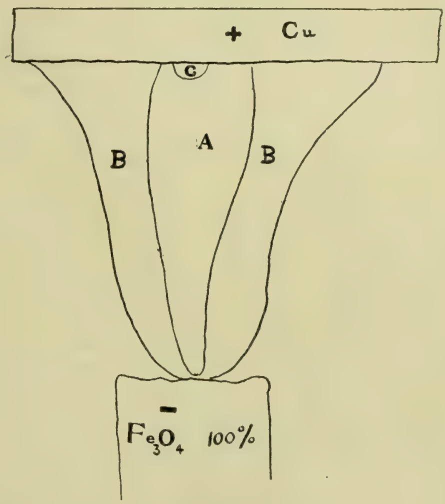


FIG. 8.

envelope B. The general tint of the light from the iron arc is blue; there is no very distinct break between the termination of the blue inner core and the commencement of the envelope. The inner core A seems to produce most of the light. This observation is not in accordance with that of Weedon, who found that the inner core of a metallic arc in general contributed little to the luminous effect, most of the light coming from the outer envelope.

Fig. 7 represents an arc between a copper anode and an iron cathode. The light is again of a bluish tint. In the magnified image of this arc one can also distinguish an inner bright blue and luminous core A, and an

aureole of a reddish-yellow tint. Occasionally a small green and feebly luminous patch of light, C, emerges from the anode.

The magnetite arc formed between a copper anode and a cathode consisting of 100 per cent magnetite presents an appearance very similar to that of the iron arc. The light is, however, now white with a slightly bluish tinge. In this case also a small green flame appears from time to time at the anode. (See Fig. 8.)

If the direction of the current is reversed the appearance of the arc changes absolutely (see Fig. 9). Under the same electrical conditions as before the core A becomes much more extended, its colouration is much darker and it is less luminous. A narrow black band now appears between the core A and the reddish-yellow mantle B.

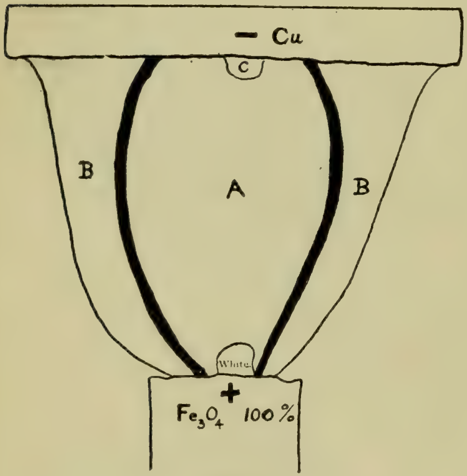


Fig. 9.

The light intensity is now about 33 H.K., whereas, with the +Cu,—Fe_3O_4, arrangement, and with the same electrical conditions (except as regards polarity), a light of 300 H.K. was obtained.

In general the appearance of an arc struck between a copper anode and a cathode composed of a mixture of other materials and magnetite, does not vary very materially. There is always a light blue core A and a yellow envelope B. But the colour of the yellow envelope varies according to the material added. Thus the addition of manganese oxide changes the reddish-yellow colouration to lemon yellow while calcium oxide renders it orange. If, however, only a very little magnetite is contained in the mixture, in some cases the characteristic light blue core vanishes. Thus Fig. 10 shows the appearance of an arc between a copper anode and a cathode consisting of 10 per cent. magnetite and 90 per cent. aluminium oxide. The inner blue core cannot be perceived even when the arc is magnified

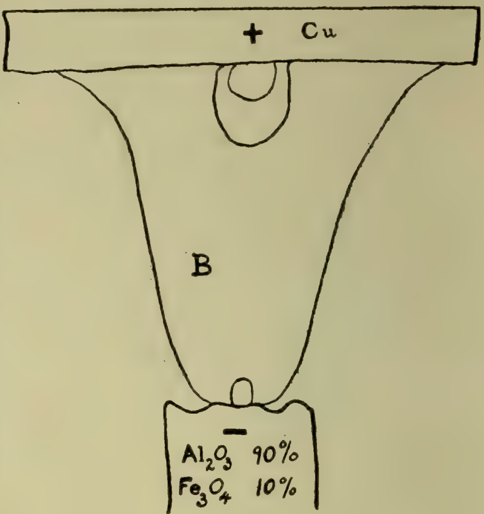


Fig. 10.

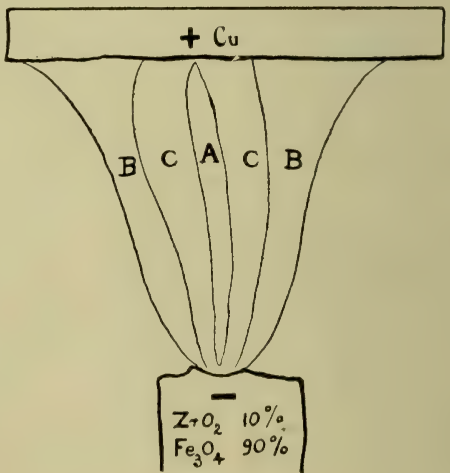


Fig. 11.

sixfold. A small green flame projects from the anode, and this is covered by a faintly luminous blue mantle. Towards the outside the envelope B assumes a deep red-yellow tint being lighter in the central portions. A small white flame occasionally appears at the cathode. The fall in luminosity of the magnetite-zirconium oxide arc, when an increasing percentage of the latter constituent is added, was studied by observation of the magnified images of the arcs, formed with various combinations.

In Fig. 11 is seen the arc produced between a copper anode and a cathode consisting of 90 per cent. magnetite and 10 per cent. zirconium oxide. It will be observed that the inner core

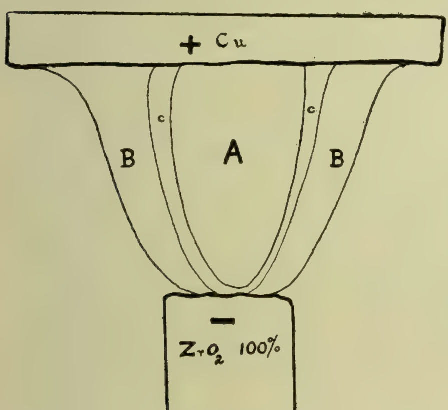


FIG. 12.

consists of two portions, a narrow bright blue and luminous strip A, and a wider region C that is quite white. The addition of more than 60 per cent. of zirconium oxide brings about a marked diminution in brightness. Fig. 12 refers to an arc in which a cathode consisting of 100 per cent. of zirconium oxide in an iron tube is used. The blue inner core A is considerably greater, darker and less luminous, and the white core C has collapsed into a narrow band. The envelope B is now a light yellow.

The most powerfully luminous arc was obtained by using a cathode consisting of 100 per cent. titanium oxide. The appearance of such an arc is shown in Fig. 13.

The core again consists of two distinct portions, as before a narrow inner light blue luminous strip A and a broader portion C, which is white,

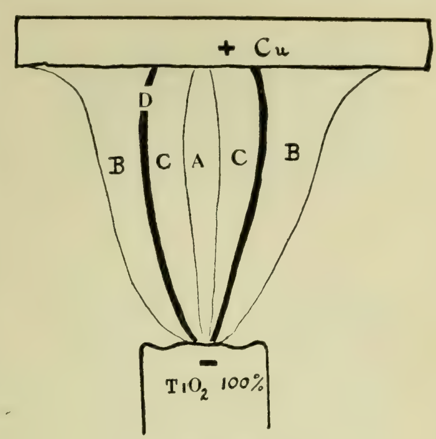


FIG. 13.

and intensely luminous. Between B and the core appears a narrow orange band D. The envelope B is feebly luminous and white in character. It is also in an unsteady condition, occasionally disappearing and blending

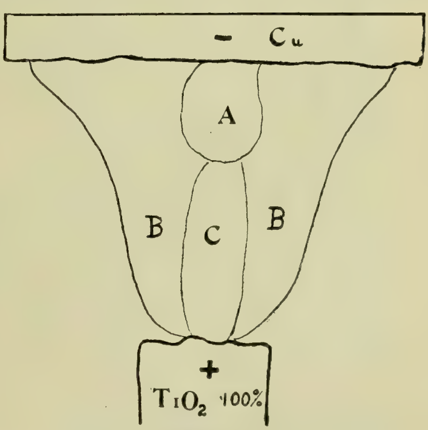


FIG. 14.

itself with its surroundings like a light mist. The horizontal illumination in this case was about 1340 H.K. When the direction of the current through the arc was reversed, so that the copper became the cathode and the titanium oxide the anode, an extremely weakly luminous arc was obtained, the horizontal candlepower being only

51 H.K. The arc is also somewhat broader than before (See Fig. 14). The inner portion of this arc consists of two distinct and differently coloured

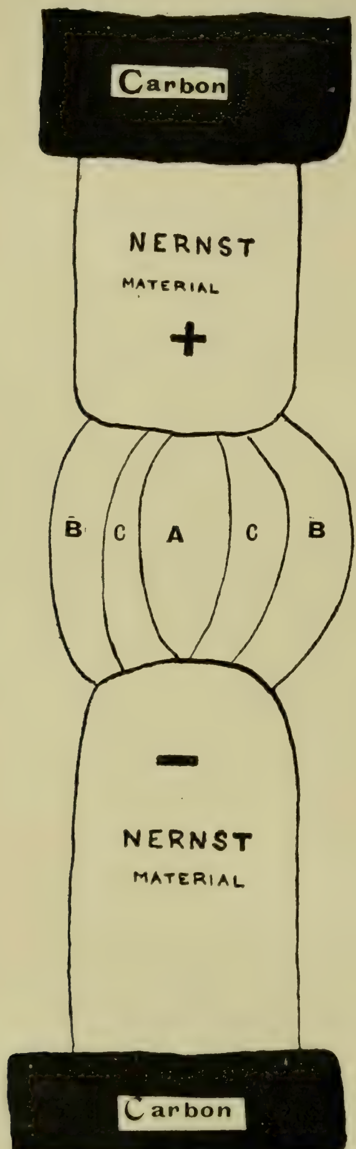


FIG. 15.

portions, a bright blue region A emerging from the copper cathode and a bright violet flame C, appearing from the titanium oxide; both give very little light. The mantle B is yellowish and its edges are not sharply defined.

III.

Fig. 14 refers to an arc struck between two rods composed of Nernst material each 8 mm. in diameter. The rods were gripped in a carbon tube and pre-heated by means of a Bunsen burner. The length of rod emerging from the carbon tube at the anode is 10 mm. while in the case of the cathode the corresponding length is 15 mm. The distance of the arc from the photometer-screen was 2·33 metres. The extremities of the Nernst rods emerging from the carbon holder were brought to vivid incandescence by the passage of a current. In order to ascertain to what extent the glowing rod contributed to the total amount of light produced, a metal screen, which could be stationed in front of any part of the luminous surface, was made use of. With a P.D. of 120 volts across the electrodes and a current of 3 amperes (supply voltage, 220 volts), the following measurements were obtained :—

1. Anode [above] and Arc (Cathode screened), 157 H.K.
2. Cathode [below] and Arc (Anode screened), 240 H.K.
3. Anode and Cathode and Arc all exposed, 339 H.K.

From these three results it appears that the light due to the arc alone is only 58 H.K. By a direct measurement, during which both anode and cathode were covered by a suitable screen, so that only the horizontal beam from the arc itself could reach the photometer, a value of 49 H.K. was obtained. It may therefore be said that when Nernst electrodes are used the light due to the arc is relatively small in comparison with that due to the solid electrodes.

As regards the appearance of the arc the inner core A is very feebly luminous and violet in colour. Adjacent to it is a white band C which seems to furnish the main portion of the light from the arc. The aureole B is also weak in luminosity and of a dark yellow-red tint.

(To be concluded.)

Further Notes on Shop-Window Lighting.

By an Engineering Correspondent.

It has been repeatedly pointed out how essential it is that any naked filaments, or other bright specks of light such as are liable to distract the attention of the customer from the goods displayed in a shop-window, should be avoided. This was insisted upon by many of the authorities who took part in the recent discussion on "Glare, its Causes and Effects," before the Illuminating Engineering Society. The habit of placing naked filaments in the windows, it was added, is not confined to any one city, and is all too prevalent. Some models of illuminated shop-windows shown at the recent exhibition in Berlin, in which this fault is conspicuous in its absence, are therefore, of interest.

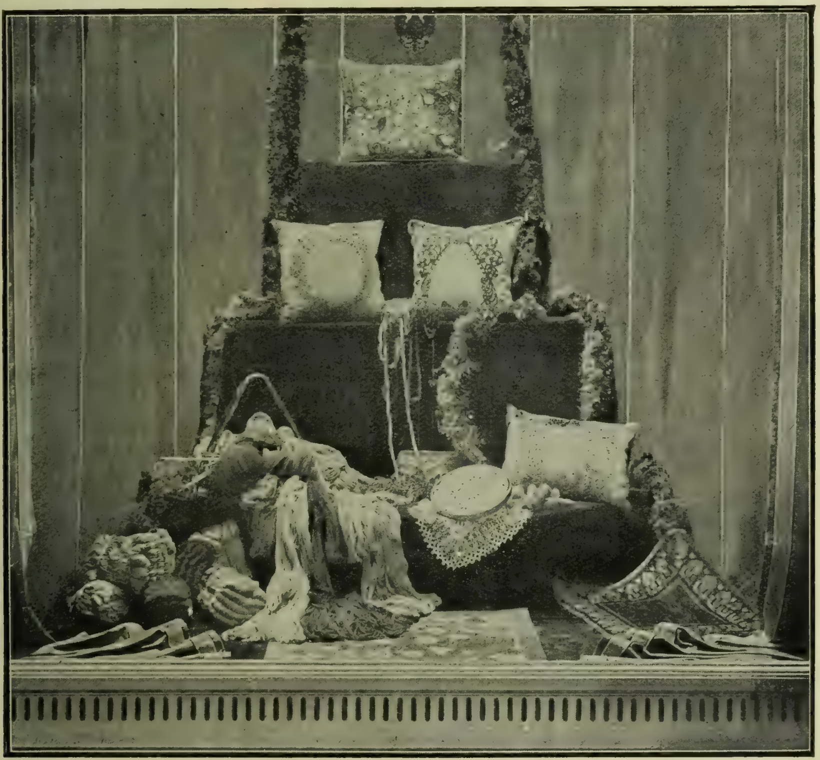


Fig. 1. *(By the courtesy of the A.E.G. Zeitschrift.*

Figs. 1, 2, and 3 refer to three such examples which were recently published in the *A.E.G. Zeitschrift.* In each case, it will be observed, there is nothing between the eye of the onlooker and the goods to distract his attention. The illumination is provided by sources out of the direct range of vision, the sole object being to flood the window with a diffused and powerful illumination.

Another feature of interest is the depth of the windows employed. This is very conducive to an effective display. When the goods are pressed close up against the glass of the window it is not only exceedingly difficult to produce any really artistic effect, owing to the absence of perspective, but there are

also difficulties in the lighting. In such cases, for example, we are often practically restricted to the method of using powerful lights outside the window, and even if these are screened in such a way as to reduce the possibility of glare to a minimum, it is still difficult to illuminate the window satisfactorily and to avoid the reflection of the bright source in the glass.

The illustrations also provide an example of another tendency in modern shoplighting on which something was said in these columns a few months ago. There is no attempt here to crowd every possible kind of article that may be inside into the windows—in short, to make them catalogues of goods. On the contrary, the idea is to make the window a pleasing and well-composed picture calculated to arrest the eye of the passer-by. The window is an advertisement. It contains comparatively few articles, but such things as it does contain are carefully arranged. Observe, for example, the artistic balance of these three windows, especially, Fig. 2. In Fig. 1 again, the exhibition of kindergarten materials and children's drawing apparatus, &c., is thought out with a view to balance; whether the observer stops to examine the contents of the window in detail, or only gives it a fleeting glance, he receives a pleasing impression. On the other hand, if he does desire to examine any object closely, it is easy to provide ample illumination for him to do so, and it will be noted that the books, &c., in which there is small detail to be viewed, are placed in the front of the window, while the larger objects are in the background.

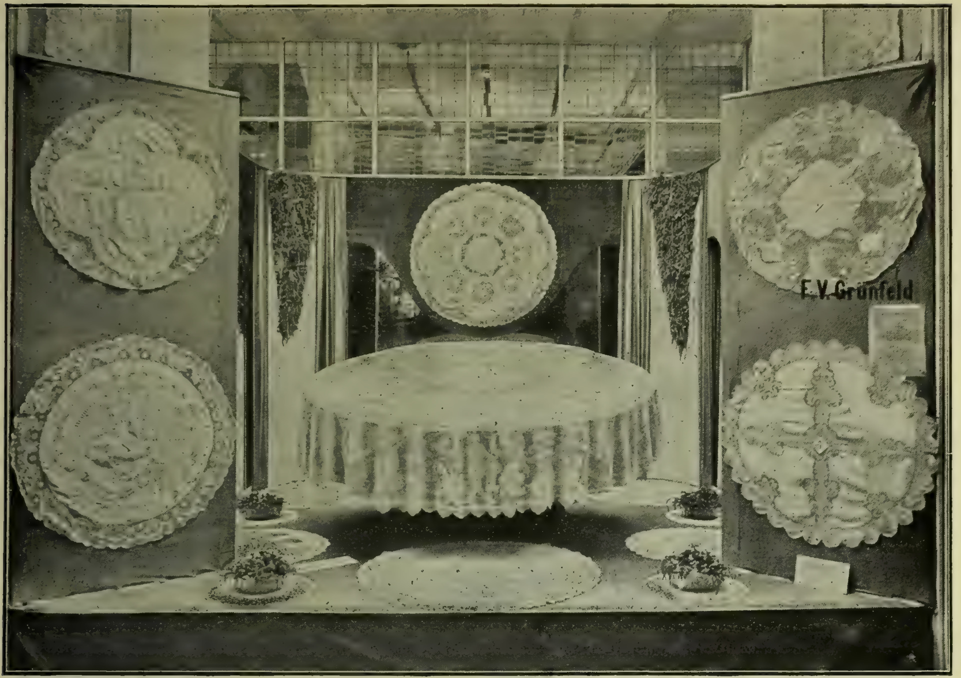
In such cases as these the prospective customer is not expected to make up his mind what he wants before he enters. He may derive inspiration from the window, but the latter is understood to be merely suggestive, and he is quite free to enter and look about without feeling pledged to buy anything. It need hardly be said that once this idea that the window is to be a picture is grasped, the possibilities of clever arrangement and judicious lighting become manifest; both factors go hand in hand. For example, the colour scheme offers endless opportunities for those gifted with taste, and so does the distribution of objects of different shapes, sizes, and qualities of surface, so as to make an artistic whole.

It is still a common thing to see all colours jumbled together irrespective of the possibility of clashing, and only the gifted few know how to exercise the necessary restraint. Some of the most striking effects are produced by using a few shades only and by striking a powerful dominant colour-note.

Directly we begin to consider the question of colour, too, we are faced with the well known influence of artificial light on the daylight appearance of coloured objects. Owing to the difference in the spectral composition of daylight and artificial illuminants, a colour-scheme which appears specially attractive by day may quite lose its effectiveness by night and *vice versa*. In such cases it is, therefore, essential to select an illuminant which approaches daylight in composition.

It is possible, however, that the use of concealed lights of different colours in the window may serve as a powerful weapon, just as in the case of the stage. The fact of the quality and intensity of artificial illumination being so fully under control is an advantage when the light is wisely used. In addition to the deliberate selection of colours, the appearance of a window may demand a certain distribution of light, depending on the kind of goods exhibited. In a deep window, for example, it may be well to remember that it is naturally more difficult to see detail at this distance. In some case it may be well to accentuate the illumination in the background, and to place there only the larger and more easily perceived articles.

Another device which has merits for deep window lighting is the arrangement of materials in rising tiers, as in Fig. 1. This arrangement often renders it easier to bring all the articles exhibited within the range of vision of the observer and yet to secure that each receives its due illumination and that the upper portion does not interfere with or screen the lower. An approximately pyramidal shape as shown in Fig. 1



FIGS. 2 and 3.—Examples of Shop-Window lighting at the Recent Exhibition in Berlin.
(By the courtesy of the A.E.G. Zeitschrift.)

also inclines the eye to look towards the apex, as in the expectation of finding there the centre of interest in the window; it might, therefore, occasionally be a good plan to accentuate the illumination at this point, and to aim deliberately at this effect.

In any window the object in view should, of course, be clearly borne in mind in arranging the illumination. As a rule it is probably desired to exhibit all the articles on show with equal prominence, and in this case one would suppose that a more or less uniform system of illumination would be needed. But in other cases it sometimes may be intended to make one special group of goods the dominant attraction, and the illumination should then be concentrated in such a manner as to assist this impression, and to lead the eye naturally in the desired direction.

A special device for window-lighting which is not without interest is that shown in Fig. 4. This is an arrangement described in a recent number of *The Illuminating Engineer* of New York. In consists in a reflector of the shape requisite to throw the light downward and backward into the window, but having its longest side (facing the street) plane. The reflector is made of opal glass stained to an opaque tint on the outside, with the exception of the plane face; upon this a single letter is stencilled. By placing a row of such letters side by side any word can be formed. In the illustration shown the word "shirts" has been traced out and the letters can, of course, be altered from day to day so as to form any desired notice without affecting the illumination of the window. The use of this fitting also provides an easy way of placing sources of light inside the window and in view of the customer, without dazzling the eye of any one looking in.

FIG. 4.—Showing Illumination of Window by means of Special Lettered Reflectors.

Standard Methods of Measuring Illumination.

By Dr. L. Bloch.

(An account of the suggestions of the Photometrical Committee of the Verband Deutscher Elektrotechniker' to be presented at the Annual Meeting this year; abbreviated translation from the *Elektrotechnische Zeitschrift*, April 15th, 1910).

In a previous number of the *Electrotechnische Zeitschrift* the following recommendations of the Verband Deutscher Elektrotechniker regarding measurements of illumination was published*:—

"The mean horizontal illumination, measured at an height of one meter above the floor or the ground, shall serve as a practical measure of the illumination of outdoor areas and interiors. In addition the maximum and minimum horizontal illumination of the entire illuminated surface should be specified.

The lack of uniformity of illumination is to be expressed in terms of the ratio of the maximum to the minimum horizontal value. The specific consumption of a system of illumination is to be expressed (in the case of electric lighting) in terms of watts per Lux (mean horizontal illumination) per square metre of floor area illuminated."

The investigations of previous commissions of standards of light on photometry, &c., were mainly devoted to the consideration of the best method of measuring light from electric sources. These investigations have now been extended to conditions of illumination.

The necessity for closer agreement on this question is very generally admitted. In most cases we do not so much desire an exact knowledge of the candle-power of the source. We desire rather to know whether a street or an interior is, at a whole, satisfactorily illuminated. In particular when we come to the comparison of different systems of lighting it is important to know not so much what the individual lights can do, but rather which of the systems is best adapted to produce the requisite general illumination. This has recently become extremely essential in view of the large number of competing systems of lighting.

The photometrical Committee appointed a sub-committee to deal with various special questions. They were specially concerned with one prcblem (which has often been the subject of controversy in the past), namely, whether it is better to measure the illumination of streets and open spaces in terms of the horizontal or the vertical illumination. There can be no doubt that in any streets both horizontal and vertical surfaces should be well illuminated, as far as it is possible to do so. But nevertheless, the calculation and measurement of one of these quantities may answer practical purposes. In studying this question the members of the sub-committee undertook an extensive series of investigations into the distribution of illumination, both vertical and horizontal, in a large number of streets. It was found that in all practical cases the vertical illumination was as great or even greater than the horizontal intensity in the situations where the light was weakest, so long as the vertical surfaces were illuminated mainly by direct light. The lowest intensities of vertical illumination were met with in somewhat unexpected positions, for example, immediately below the lamps or in very immediate proximity to them; these are just the situations where the horizontal illumination is usually highest. The measurement of these minimum values of the vertical illumination is rendered very difficult by the fact that slight differences in the position of the plane give rise to such large variations in

* *E.T.Z.*, Vol. 12, 1910, p. 363.

results. In addition the specification of the vertical illumination at any point in the street demands that measurements should be taken in at least four different directions, whereas the horizontal illumination at any point has only a single value. The calculation as well as the measurement of vertical illumination is also much more difficult and tedious than is the case of horizontal illumination, especially when the points considered fall outside the line between two of a row of lamps.

The tests undertaken by the Photometrical Committee also showed that the vertical illumination tended to appear relatively high in comparison with the horizontal in the case of lamps hung at low level. This was already well known. On the other hand, this system of lighting is certainly not to be recommended and recently the tendency has been in the direction of increasing the height of lamps above the street so that less of their light is thrown in a horizontal direction. By this means excessive glare is avoided and it is also possible to secure a greater uniformity of illumination. In the most important streets it is also now considered advantageous for lamps to be placed over the middle of the roadway, whenever possible, although, under these circumstances, a vertical surface facing the side of the street would receive practically no direct light. This, again, serves to show that the maintenances of vertical illumination is in practice regarded as only of secondary consequence.

The sub-committee discussed all these points in a very thorough manner, and came to the conclusion that the specification of illumination in a horizontal plane alone sufficed, and that an additional statement of the vertical illumination was not necessary. This also holds for interiors where we are usually concerned mainly with the light falling on horizontal surfaces such as tables, &c., and the illumination of the vertical surfaces, such as walls, usually has no special interest. There are, of course, exceptional cases, such as picture-galleries, libraries, &c., which naturally demand special treatment.

The Committee next proceeded to discuss the height above the ground level at which measurements should be made. In the case of streets the illumination of the ground is of the greatest consequence. On the other hand it is extremely difficult, and as a rule impossible, to carry out measurements at the level of the pavement with an ordinary type of photometrical instrument. Even when a specially designed photometer for this purpose can be employed the tests will be seriously interfered with by the scattering of mud from the roadway, and the shadows of unwelcome spectators. On these grounds it appears desirable to specify that the calculation and measurement of horizontal illumination should take place in a plane at a prescribed height above the ground level. Having regard to the fact that the differences between the illumination on the ground and that at a parallel plane a few feet above it is usually relatively trifling, the Committee determined to depart from the height still frequently adopted, namely 1·5 metres above the roadway, and to substitute a distance of 1 metre. This height answers equally well for outdoor illumination and for the inside of buildings. One metre is also the height of measurement that seems to be most generally adopted for indoor work at the present time, and is about the same as the distance from the floor of the ordinary table. The recommendations for the measurement of illumination in streets, squares, and open spaces, therefore, could also be regarded as applicable to interiors.

The sub-committee recommended further that the mean, maximum, and minimum horizontal illumination should always be stated. By the mean value is naturally understood the average for the entire illuminated surfaces, and not merely the arithmetical mean between the maximum and minimum values. In determining the vertical values of illumination due consideration must, of course, be paid to the practical limits of the illuminated surface. The maximum and minimum values should, as far as possible, represent the result of tests in several

different positions, and should not be chance or "freak" values which do not represent the general conditions. The ratio of the maximum to the minimum horizontal illumination serves as an indication as to whether the system of illumination is more or less uniform.

The last point to be considered was the conception of specific consumption. It was agreed that in the case of electrical installations this consumption should be expressed in watts and in the case of gas in litres of gas per hour, on the basis of a production of one Lux mean horizontal illumination per square metre of area illuminated.

The decisions of the sub-committee have been adopted by the Photometrical Committee, and will be laid before the Verband Deutscher Elektrotechniker at their annual meeting, with the recommendation that they should be provisionally adopted for one year. During this time it should become evident whether the suggested standard terms and methods will be convenient in practice or whether any modifications are desirable. The recommendations will also be submitted to the Verein von Gas und Wasserfachmännern with the request for their consideration, and, if possible, tentative adoption. On these points the co-operation of all engineers connected with lighting problems is earnestly desired, and will, it is hoped, gradually be secured.

Illuminating Engineering and the Sale of Gas Appliances.

We have received from Mr. Norman Macbeth, lighting expert to the Welsbach Company in the United States, an admirable booklet entitled 'Engineering Data on the Welsbach System of Illumination,' which certainly deserves the notice of those interested in the sale of gas appliances in this country. The book is of a convenient size, 9 in. long, 5 in. wide, and about half an inch in thickness, and is handsomely bound in leather. It is issued to gas engineers and companies "for exclusive use in the advancement of incandescent gas illumination."

The book commences with a few instructions regarding lighting specifications and particulars as to the dimensions and characteristics of interiors on which advice is sought. It is interesting to note that a broad distinction is drawn between cases in which the artistic element predominates and expense is of secondary importance, cases in which both factors have to be considered, and cases in which cheapness is a *sine qua non*. There are also diagrams and tables enabling the horizontal illumination from a source at a given height to be obtained, and energy curves of different illuminants on the basis of equal illumination.

What, however, is the specially attractive feature of the volume is the complete numbered series of excellent photographs of different incandescent gas lamps, each equipped with its characteristic shade or reflector. Each photograph is immediately preceded by a diagram giving the polar curve of light distribution of the source, its mean spherical and mean hemispherical candle power, the output of the source in lumens, and the necessary data regarding the reflector used. Readers will observe that a diagram of this kind was described by Mr. Macbeth in his contribution to the discussion of the Illuminating Engineering Society in our last number.*

Naturally such a series of photographs and diagrams presents an excellent record, enabling an engineer to know and readily explain what can be expected from any particular fixture and lamp. It is also interesting to note that the series is to be kept thoroughly up to date, holders of the book receiving, from time to time,

* *Illum. Eng.*, Lond., May, 1910, p. 319.

numbered revised diagrams and photographs of more recent developments, to be filed in their appropriate positions.

A second publication from the Welsbach Co. is a pamphlet bound in similar style to the above, and containing advice and instructions to canvassers and salesmen of gas appliances. Here again the appeal to the purchaser is based on information. The canvasser is recommended to use complimentary letters with discretion, only selecting those which contain valuable confirmation and bear directly on the point under consideration. The importance of doing everything possible to make things clear and agreeable to the consumer is insisted upon. Condensed information is given on important points in connexion with illumination in order that the claims on behalf of the illuminant, lamp, or fixture recommended may be substantiated by reference to reliable published figures on the subject.

Salesmen are specially advised to make themselves familiar with other systems of lighting. "In the sale of gas illumination the question of electric rates should be carefully studied."

In this connexion we should like to quote entire the advice on the subject of illuminating engineering :—

"When, as a gas company salesman, you advise the use of the right lamp in the right place, you are practising illuminating engineering—doing all that the engineer would do. You should know something about the principles of illuminating engineering, and the differences between good and bad lighting. Do not exaggerate the advantages of gas illumination—you don't have to. Don't waste your time in the attempt to prove that gas illumination is cheaper than other methods; your customer knows that now, but he may not know the advantages which modern equipment has placed at his disposal.

There is not a single artificial light source or system to-day which is one hundred per cent criticism proof, when all the returns are in."

In the further pages of the booklet tables and information on a number of special points are given. For example, the lighting hours at different times of the year, the intensity of illumination required for different interiors, the absorption of various surfaces, &c., are summarized. Special attention is devoted to window lighting. Lastly, stress is laid on the desirability of avoiding the glare of bright sources in the field of vision. "Repeated experiments and experience prove conclusively that clear globes interfere with clear vision."

The Care of Lighting Devices.

People are not wanting who appear to think that a lighting device, a generator for instance, should run indefinitely almost without thought or care as to the apparatus itself. If the same attention is given to cleaning the generator scrupulously that is given to the care of a mowing machine or bicycle or engine, the results would be much better.—(*The Acetylene Journal*).

Light in Exchange for Advertising.

An interesting plan for lighting streets in the city of Indianopolis, in the United States, has been recently adopted. A Chicago company has offered to light the streets free of cost in consideration of the privilege of utilizing the lamps for advertising devices. This proposal has been agreed to, and it is said that the change will be the saving of over 10,000 dollars a year to the city (*Elec. Rev.*, N.Y., August 14th).

Light, heat, and power companies must be lenient, even to a point where leniency means almost certain loss. The wisdom of this statement is plain when we stop to consider—how can it be hoped that the debtor will storm his financial distress if he be deprived of light, heat, and power ?—*Light*, July, 1909.

Some Architectural Considerations Affecting the Design and Position of Lamps and Fixtures.

(Abstracted from certain articles by Dr. R. Bernoulli in recent numbers of the *Zeitschrift für Beleuchtungswesen.*)

In olden days lamps and their accessories were looked upon in an entirely different light from what they are to-day, and it is very striking to observe how far we have departed from the ancient standpoint in matters connected with lighting. In the past the illuminants available were so feeble that their practical use, as a means of illuminating the surroundings, was almost relegated to the background. When a lighting fixture was designed it was regarded primarily as a decoration, and, in the hands of the architect, as a legitimate means of accentuating and embellishing his effects. To-day the architect not infrequently concerns himself but little as to the nature of the lighting fixtures installed, leaving the matter in the hands of the engineer and the contractor, and scarcely considering whether they are likely to add to or detract from the effect of his designs.

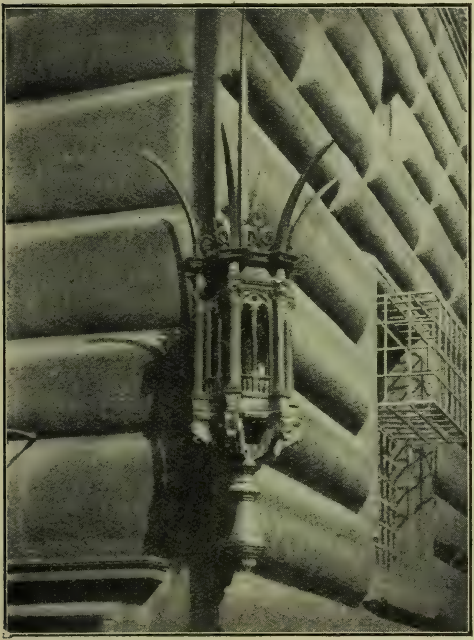


Fig. 1.—Ancient Ironwork Lantern, Palazzo Strozzi, Florence.

Fig. 2.—Staircase Illumination, Herberstein Palace, Graz.

(*By the courtesy of the Editor of the "Zeitschrift für Beleuchtungswesen."*)

The deviation of modern practice from that of the past has been emphasized in a series of interesting articles by Dr. R. Bernoulli in the *Zeitschrift für Beleuchtungswesen* during the last few weeks, and we are indebted to the courtesy of the editor of that journal for the illustrations, taken from two of these articles, which accompany these remarks.

The first three illustrations represent various ancient types of wall and stair-

case lamps. The iron lantern shown in Fig. 1 forcibly illustrates the contrast between the ancient and the modern. The value of this lamp as a means of illuminating surroundings, it is pointed out, was evidently of quite secondary importance. Its position and design were determined by architectural considerations, and were made wholly subservient to the architect's design. The staircase lamp shown in Fig. 2, again, has been seized upon as an opportunity for ornamental embellishment.

As our methods of lighting have become more efficient, the decorative possibilities of lights seem to have received less and less attention. The production of a powerful uniform illumination in our streets by severely practical arc-lamps and incandescent gas-lamps has replaced the occasional use of wall lamps characteristic of the days of oil and candles. Yet one cannot but wonder whether the decorative aspects of the question ought not often to receive closer attention than they do. We value artistic and architectural feeling in our buildings. Why, therefore, should we not occasionally consider the same qualities in the use of light, and deliberately employ lamps of appropriate design simply as decorative objects and not for the purpose of enabling us to see our way about? One would suppose that, in the hands of an expert gifted with the necessary artistic perceptions, light so used might add greatly to the permanent charm of a city. In selecting the lamps used on bridges, for example, might we not consider the effect, as decorative objects, of a row of such lamps seen from a distance above the water, and the desirability of mounting them in lanterns and on pillars in harmony with its architectural proportions?

FIG. 3.—Spanish Room, Imperial Castle, Prag.
(*By the courtesy of the Editor of the "Zeitschrift für Beleuchtungswesen."*)

When we come to the illumination of interiors, we are still more impressed by the extent of the influence of principles quite outside the ordinary engineering aspects of lighting. Mr. W. Basset Jones, in a well-known paper on this subject,* has stated that the amount of light a room requires, from the æsthetic standpoint, is determined by special considerations quite apart from such practical points as the intensity required for reading, &c. The light required in an artistic interior depends not only on the extent and quality of detail to be exhibited, but also on a whole chain of mental association brought into play by the history and character of the room.

Dr. Bernoulli, again, points out how the design of a fixture, in the case of interiors of this kind, must obey certain canons, which have nothing to do with its serviceability as an illuminant. The different parts of a room have each their distinctive characteristics, and their architectural form has developed accordingly. For example, the form of the pillars and pilasters in an interior is modified by their intention of giving support. Dr. Bernoulli compares the lamps in a room with the fruit on a tree, which, though it may require substantial limbs to bear it up, is merely an appendage. The dimensions of the fixtures must, however, be such as to give the impression of being able to support the lamp attached to them, and they should also be sufficiently massive to be in proportion to the interior; note, for example, the massive chandeliers shown in Fig. 3. Again heavy fixtures of this class should be attached to something which is obviously capable of giving the necessary support. When brackets are used, therefore, it is often advantageous to attach them to pillars (as in Fig. 3), which are recognized to act as supports of the room, and are proportioned accordingly. But the brackets should not themselves be so extensive as to obscure the pillars and prevent their purpose being clearly evident.

In the same way, when heavy fixtures are attached to the ceiling there should be some indication that the portion to which they are attached can bear their weight. In order to strengthen this impression a white ceiling is usually provided with special moulding near the base of the support. Any method in which there appears to the eye to be no satisfactory means of support (if, for example, the fixture projects from a mirror surface) would be condemned on artistic grounds.

Yet another way in which architectural considerations operate is in deciding the location of a hanging fixture. From the practical standpoint a fitting is placed where it can most efficiently distribute its light. From the architectural standpoint, however, its position may be determined mainly by the sense of proportion and balance with its surroundings.

All these considerations apply mainly to interiors in which the artistic and architectural aspects are of paramount importance. There are, however, probably few buildings of any importance with which the illuminating engineer has to deal in which they can be entirely neglected.

* *Illum. Eng.*, Vol. I., 1908, p. 400.

Forthcoming Lectures on Illumination.

It is always satisfactory to receive evidence of the spread of knowledge on matters connected with illuminating engineering. Our attention has been drawn to a series of three lectures to be delivered at the East London Technical College (Mile End Road, London, E.), on "**The Technical Aspects of Interior Illumination,**" on **June 8th, 15th,** and **22nd.** The first two lectures will deal with gas and electric lighting, and will be delivered by Prof. J. T. Morris, and the last of the series, on air-gas, by Prof. C. A. Smith.

Tickets of admission can be obtained on application to the Principal of the College.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

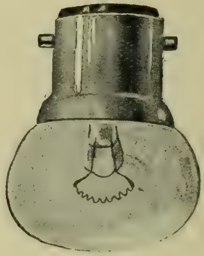
The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

"Onewatt" Metal Filament Battery Lamps.

In the last number of this journal reference was made to the "Onewatt" drawn wire tungsten lamps now placed upon the market. We have since received particulars of the small battery lamps of the same make. These also utilize drawn wire metallic filaments, and are stated to burn at a specific consumption of 1 watt per c.-p. The lamps are supplied in a series of different shapes. Those of the "Pea" type range from 1·3 to 5·5 volts and 0·25 to 1·5 c.p.; in flame candle shape from 2 to 5·5 volt; in the Pipless round shape from 1·3 to 4 volts, and from 1 to 4 c.-p. A wide range of lamps is available from 2 to 16 volts in spherical bulbs, and from 8 to 16 volts in bell-shaped bulbs.

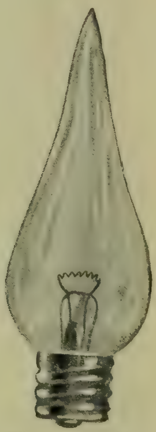
"Onewatt" Battery lamps, for motor-car and yacht lighting, are supplied in the tubular shape from 4 to 8 volts (3 to 6 c.-p.). The "Festoon" and "Side pip Mushroom" types have a very similar range of P.D. and candle-power.

Some of these shapes are exhibited in the accompanying illustrations. Full particulars and lists relating to these lamps can be obtained from **Messrs. Siemens Bros., Ltd.** (Tyssen Street, Dalston, London, N.W.).



Type C.

"Pea Shape."



"Flame Candle Shape."

"Tantalum" Athletic Club Concert.

At the recent first annual concert of the "Tantalum" Athletic Club, connected with Messrs. Siemens Brothers, Dalston Works, held on Monday evening, a highly interesting programme was arranged, in the Assembly Hall of the Dalston Central Mission. It may be added that the hall was illuminated by "Tantalum" and "Onewatt" lamps. We understand that the talent available was drawn entirely from the works staff and that the enjoyable items rendered proved that there was no lack in this respect. A novel feature was a singing competition, open to all employees of the firm, for which prizes were offered, the efforts of the competitors being adjudged by the audience. The proceeds of the entertainment are to be devoted to the newly formed "Tantalum" Athletic Club.

Contracts Closed.

The tender of Messrs. Siemens Bros. for the supply of tantalum lamps has been accepted by the Walthamstow Urban District Council.

The Automaton Distance Gas Lighter.

One interesting gas exhibit at the recent Municipal and Public Health Exhibition was the Automaton Gas Lighter of **Auto Lighter, Ltd.** (17, Victoria Street, London, S.W.).

A number of devices for lighting up and extinguishing of street gas lamps at a distance have been recently described. One important class depends upon the use of a temporary rise in pressure in the gas mains, this rise being applied at the station when it is desired to turn the lamps on and off.

It is impossible, in the space at our disposal, to give any complete idea of the mechanism of the "Automaton" lighter. Readers who desire this should examine the apparatus for themselves. Its special claim, however, is that it can be specially suited to the exact requirements of any particular district. Most engineers in charge of a gas works have their own special methods, and the local pressure usually undergoes occasional transitory fluctuations for which it is sometimes necessary to make provision in installing any automatic device on the lamps in the locality. Now this apparatus is adjustable within wide limits, and can be set so that it is unaffected by any desired range in pressure. It is said to have given great satisfaction in Croydon and elsewhere.

It is also contended by the maker of this device that an apparatus which relies upon the actual power of the rise in pressure to work its mechanism, and so to light up the lamp, must to some extent suffer by the presence of a variable degree of friction. As a result the exact amount of pressure required to put the lamps on or off is a little uncertain. Occasional vibrations may have the effect of lessening the friction for the moment, and causing a row of lamps to light up when they should not; and only a few exhibitions of lamps alight in broad daylight is apt to excite the ridicule of the public. In the Automaton device the motive power is provided by clockwork. The rise in pressure only "pulls the trigger," and it is contended that the possibilities of friction interfering with the apparatus are reduced to a minimum.

By a slight modification the device can also be adjusted to work on a falling pressure instead of a rise. It can also be arranged to extinguish only one of a pair of burners at a given time, so that, after the busiest part of the evening is over, a smaller amount of gas can be consumed, and an economy thereby derived.

A Souvenir of "Electra House."

We have received a copy of the Souvenir, now being issued, of the model electric home, arranged by the South Metropolitan Electric Light & Power Co., at 111, Bromley Road, Catford; to this reference has previously been made in this journal as an illustration of the tendency of modern electricity supply companies to make special efforts to interest the consumer.

The booklet contains a bright description of the fixtures and methods of electric lighting employed. The uses of electricity for heating are also not neglected, attention being drawn to the electric combs, irons, hot water and cooking appliances, and other devices.

There are also one or two rather interesting examples of special uses of electric light. We notice, for example, the existence of an illuminated notice of the name and number of the house so that it can readily be found by night. This is a feature which many suburban householders would do well to copy. Another ingenious device is the projection of an illuminated clock dial on to the ceiling of a bedroom so that any one lying in bed, by merely touching a button, can look up and see the time above him.

Any further particulars can be obtained from the company at their offices (183, High Street, Lewisham, London, S.E.).

Reduction in Price of Tantalum Lamps.

We have received from **Messrs. Siemens Bros. Dynamo Works, Ltd.** a notice of a reduction in the price of Tantalum lamps which is to come into force on June 1st, 1910. A list of these prices can be obtained on application by contractors and dealers. We note that 50-80 volt and 100-120 volt lamps, of 16 candlepower, will cost 1/6 and 2/ respectively in the standard bulbs; 50 C.P. lamps for 100-130, 140-160, and 200-250 volts will be 2/, 2/6, and 3/, respectively. The discounts, terms for contracts &c. will remain as hitherto.

The "Lamlock" Electric Lamp-locking Clip.

A Simple Means of Preventing the Stealing of Electric Lamps.

In a recent number of this journal* a contributor drew attention to the temptation to theft of the more expensive metallic filament lamps, it having been not infrequently found that a considerable number of lamps were taken from their sockets during the night.

We have received particulars of a simple device for locking the lamp-holder and preventing thefts of this kind. The "Lamlock" device, shown in the accompanying illustration, consists of a metal clip with a slot in it, there being also a hole fitting over the pin in the cap so as to bring the slit just opposite the slot in the bayonet holder. The metal is then bent over on either side of the slit by the blade of a knife so that the projection prevents the lamp being removed from the holder.

We understand that the price of the clips is only 5*s.* per gross, and that they have been utilized by Messrs. Lyons & Co., Hotels Savoy and Cecil, the Great Western, Central London and other railway companies in large quantities.

Further particulars are obtainable from Mr. C. H. Jeffcoat, 2, Marchmont Court, Addison Gardens, London.

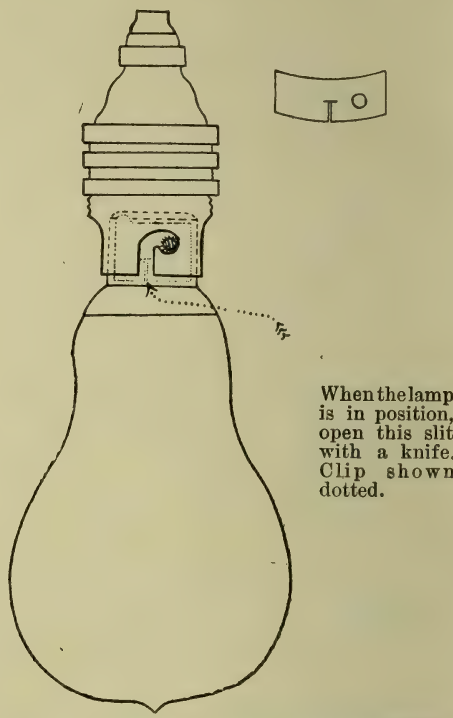


Fig. 1.—"Lamlock" Electric Lamp-locking Clip

* *Illuminating Engineer*, Lond., April, 1910, p. 275.

Osram Lamps on Board Ship.

The use of metallic filament electric lamps has done much to improve the conditions of illumination in ships, where the space available is often very limited, the ventilation not all that could be desired, and the access of daylight to cabins, &c., considerably restricted. The great majority of the ocean-going liners are now equipped with their own electric lighting plant. It is therefore possible for the most convenient and fairly low electrical pressure to be generated so that metallic filament lamps can often be used under the most advantageous conditions.

We have received some particulars regarding the use of Osram lamps on one of the White Star Liners, which has just returned to port after a five months' cruise. The engineer states that only one lamp failed during this period although the average life of the lamps installed already exceeds 700 hours. Encouraged by this result, the vessel is putting to sea again with only half the usual number of spare lamps.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

During the past month there has been a variety of contributions appearing in the United States, including some papers of special interest before the United States Illuminating Engineering Society. Thus in the January number of the *Transactions* **V. R. Lansingh** contributes a paper dealing with The Design of Reflectors. It contains photographs of a number of different fixtures the corresponding polar curve of light distribution being attached in each case. Another interesting paper in the same volume is that of **G. E. Hulse** on the Lighting of Railway Carriages. The data presented are unusually complete, and a summary is made of the qualities of the chief methods of lighting, acetylene, oil-gas, and electricity available for carriage - lighting. There are photographs of a number of different installations and full particulars of the position of the lights, the kind of shades used, and the distribution and intensity of illumination over the carriages. All this is presented in a convenient tabular form.

The subject of Street Illumination again absorbs a considerable amount of attention. **Dr. L. Bell**, in a recent paper before the Illuminating Engineering Society (abstracted *Elec. World*, N.Y., April 16th), discusses street photometry. He professes to be able to obtain an accuracy as low as half per cent in the laboratory, but only much more approximate results can be looked for in the measurement of illumination. A special difficulty is presented by the unsteadiness of many street sources, *e.g.*, flickering of arc-lamps and fluctuations in the pressure of incandescent gas lamps. In one case the pressure varied from 1·5 to 3·5 inches in a single evening. An important article by **Dr. L. Bloch** (*E.T.Z.*, April 14th), dealt with the Recommendations of the Verband Deutscher Elektrotechniker regarding the measurement of illumination in streets. It is suggested that, both in the case of interior and exterior lighting, measurements should be made in an horizontal plan at a height of one metre above the floor or ground. These suggestions are to be put before the Verband at their next meeting for tentative adoption for one year.

Another valuable paper is that of **A. J. Sweet** (*Journal of the Franklin Institute*, May, 1910) the author analyses the nature of good street lighting placing special emphasis on the avoidance of glare. He describes researches as a result of which he comes to the conclusion that rays reaching the eye at an inclination of less than 60 degrees to the vertical have relatively little influence in causing glare. Rays outside this angle should therefore be excluded in street lighting. With this object, and also in order to provide uniform illumination, the ratio of the distance between two lamps to the height of the lamp post should be about 4. At present it is sometimes as high as 15.

The recent decision of the Westminster Street Lighting Committee in London is still the subject of much comment, and also the position of the local Government Board in connexion with street lighting. It is again pointed out that if this authority uses its influence or makes recommendations on the subject they ought to be backed by adequate authority, and to receive the assistance of photometrical experts.

Another subject which has received attention is School Lighting. **Hatch** (*Electrical World*, N.Y., April 21), expresses his views in a recent paper before the American Illuminating Engineering Society. He lays special stress on the need for the closer study of tinted walls and ceilings. A completely shadowless illumination is unsatisfactory. An improvement in the daylight illumination may often be made by covering the windows by a diffusing translucent shade. **A. J. Marshall** (*Illuminating Engineer*, May, 1910), describes an interesting experiment, extending over several weeks, in which the effect of different systems of lighting on one of the pupils in a school was studied in detail. A feature of the system recommended by the author is the use of amber coloured paper and similarly tinted illuminants. The vision of the student examined is stated to have distinctly benefitted by the improved lighting conditions.

There are a number of other interesting articles which can only receive brief attention. Thus **C. O. Baker** deals with Opaque Reflectors (*Illuminating Engineer*, N.Y., May, 1910), **W. E. Barrows** and **F. M. Scantlebury** contribute general articles dealing with interior lighting and the distribution of artificial lighting respectively (*Electrical Review*, N.Y., April 16, May 14); the latter gives a summary of the fundamental conditions underlying the reflection light and the design of shades and reflectors.

ELECTRIC LIGHTING.

Jehl (*Elec. World*, N.Y., April 28) gives a description of the tests of street lighting by electricity and gas in Budapest. A feature of these tests is the composition of the special committee which included a special expert from Berlin, appointed to supervise the carrying out of the measurements. The results are favourable to the electric lighting in this locality.

E. L. Elden (*Elec. Rev.*, N.Y., April 30) presents a table illustrating the effects of change in pressure on the life and efficiency of glow-lamps. He also points out that, when the electric supply company undertake the renewal of lamps, an excessive pressure is unprofitable. The consumer gets more light, but the company has to supply him with more lamps during a given period. The author therefore advocates the use of automatic regulators on different portions of the circuit, and contends that the cost of the apparatus would be compensated for by the saving in other respects. **Fink** (*Elec. World*, N.Y., May 12) describes the manufacture of Ductile Tungstens. Several companies in the United States can, by this means, make lamp filament of drawn tungsten under 1/1000 inch diameter.

Knip (*Phys. Rev.*, May) describes a form of Quartz Tube Mercury Lamp for bacteriological purposes. **Righi** (*Lumière Electrique*, April 9), A Three Phase Arc-Lamp utilizing three carbons attached to the supply mains, and one common unattached electrode.

T. Muller (trans. *Electrician*, April 29) has recently described a method of testing the strength of metallic filaments. This consists in allowing a rubber ball to roll a prescribed distance down an inclined plane before striking the lamp bulb. The distance it must roll in order to break the filament is a measure of its strength.

GAS, OIL, AND ACETYLENE LIGHTING.

The same subjects continue to receive attention. The Lighting of Westminster is still being discussed, and the question of Burner Maintenance has been much to the fore. It is realized that in the case of gas lighting it is particularly desirable that the consumer should be induced to keep his burners and mantles in good order. It has also been suggested in some quarters that a special company should be formed to look after consumer's lights.

Several papers in the United States press, notably those of **Lansingh** and **Rowe** (*T.I.E.S.*) and **C. W. Hare** (*Am. Gas Light Jour.*, April 25) deal with large Display Buildings. That of the United Gas Improvement Co., is stated to be the largest of its kind in the world. The four-storey building of the Consolidated Gas Co. in New York is another case in point. Different varieties of interiors, such as libraries, dining and drawing rooms, &c., are specially furnished and lighted as models. A special feature in the reception room is an instrument rejoicing in the name of the "sochrodometer" for testing the effects of different illuminants on coloured goods. Small booths are also erected in order to illustrate the effects of coloured wall papers.

W. Grix (*J. and G.*, May 21) discusses Self-Lighting Devices of the type utilizing small pellets which become incandescent when exposed to a stream of gas. In such cases it is essential to provide for the pellet being withdrawn from the flame as soon as the gas is lighted, and the author describes an arrangement, utilizing metals having a different co-efficient of expansion, which enables this to be done.

Another Distance Lighting Apparatus is the "Automaton" (*J.C.L.*, May 3rd) which depends on the effect of a temporary rise of pressure in the mains. An essential feature of the apparatus is that the rise of pressure does not actually move the cock and turn the gas on, but only releases certain clockwork, and so to speak "pulls the trigger."

Among other articles we may note the continuation in the *Zeitschrift für Beleuchtungschesen* of the account of recent patents on Inverted Mantles and in connexion with Incandescent Petroleum and Spirit Lamps. A rather interesting note in the American *Gas Light Journal* deals with what may be termed "furniture lights" *i.e.*, the attachment of incandescent gas lights to tables, reading stands, &c. In the case of tables a novel arrangement is to have a stand lamp at each corner.

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*

E. T. Z.—*Elektrotechnische Zeitschrift.*

G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. G. L.—*Journal of Gaslighting.*

J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

ILLUMINATION AND PHOTOMETRY.

Baker, A. O. Notes on Opaque Reflectors (*Illum. Eng.*, N.Y., May.)
Barrows, W. E. Theoretical Notes on Interior Lighting (*Elec. Rev.*, N.Y., April 16).
Bell, Dr. L. Street Photometry (*Elec. World*, N.Y., April 21).
Bloch, Dr. L. Erläuterungen zu den Normalien für die Beurteilung der Beleuchtung (*E. T. Z.* April 14).
Editorials. The Efficiency of Light Sources (*Elec. Rev.*, N.Y., Apr. 16).
The Danger of Ultra-Violet Light (*Elec. World*, N.Y., May 5).
Photometric Units (*Electrician*, May 6).
The Local Government Board and Street Lighting—Rival Illuminants (*Electrician*, May 20).
Street Lighting (*Elec. Review*, May 6).
Illumination and Visual Acuity—Eyestrain in Health and Disease—Illuminating Engineering and Colleges, &c. (*Illuminating Engineer*, N.Y., May).
Hatch, B. B. Schoolroom Lighting (*Elec. World*, N.Y., April 21).
Hulse, G. E. The Lighting of Railway Cars (*T. I. E. S.*, Jan., 1910).
Ives, H. Scattered Light in Spectrophotometry and a New Form of Spectrophotometer (*Phys. Rev.*, April).
Lansingh, V. R. The Scientific Principles of Globes and Reflectors (*T. I. E. S.*, Jan., 1910).
Sweet, A. J., An Analysis of Illumination Requirements in Street Lighting (*Jour. Franklin Inst.*, U.S.A., May 1910).
Wohlauer, A. A. The Calculation of Illumination by the point to point Method (*Elec. World*, N.Y., May 12).
Illuminating Engineering Society (London), First Annual Meeting (*G. W.*, May 28 ; *J. G. L.*, May 24 ; *Electricity*, May 27 ; *Elec. Times*, May 26, &c.).
The Danger of Glare from Electrical Headlights (*Elec. World*, N.Y., April 28).
Residence Lighting (*Elec. Field*, May).
New Photometric Processes (*Illum. Eng.*, N.Y., May).

ELECTRIC LIGHTING.

Basch, C. Die Glühlampenindustrie (*E. T. Z.*, May 12).
Editorials. The Flaming Arc in Street Lighting (*Elec. World*, N.Y., April 28).
Incandescent Lamp Ratings (*Elec. World*, N.Y., May 5).
Elden, E. L. The Effect of Regulation on Incandescent Lamps (*Elec. Rev.* N.Y., April 30).
Fink, C. S. Ductile Tungsten (*Elec. World*, N.W., May 12).
Jehl. Street Lighting in Budapest (*Elec. World*, N.Y., April 28).
Knipp, C. T. A convenient form of Quartz Tube Mercury Lamp (*Phys. Review*, May, 1910).
Müller, T. Testing the Mechanical Strength of Metallic Filaments (*Electrician*, April 29).
Righi, A. A Three-Phase Arc-Lamp using four Carbons (*Lumiere Electrique*, April 4).
Electric Lighting by Metallic Filament Lamps (*Elec. Mag.*, April, May).
Les Origines de l'Éclairage Electrique (*Rev. des Eclairages*, May 15).
The Special Illumination of Tacoma Armoury (*Elec. World*, N.Y., April 21).

GAS, OIL, AND ACETYLENE LIGHTING.

Editorials. The Lighting of Westminster (*J. G. L.*, April 26, May 3).
Gas and Electricity Deficits (*J. G. L.*, May 3).
The Economy of Small Lighting Units (*J. G. L.*, May 3).
Burner Maintenance (*J. G. L.*, May 10, 17 ; *G. W.*, May 7).
Grix, W. Gasselbstzünder (*J. f. G.*, May 21).
Hare, C. W. A Model Store Building for displaying Gas Goods (*Am. Gaslight Jour.*, April 25 ; *Prog. Age*, May 16).
Humphreys, N. H. Competition in Public Lighting Service (*J. G. L.*, May 3).
Johnson, L. H. High Pressure Distribution Problems (*J. G. L.*, May 17).
Key, W. Petrol Air Gas (*J. G. L.*, May 24).
Moskowitz, M. High Pressure Acetylene Practice (*Acetylene*, May).
Rowe, E. P., and Lansingh, V. R., Modern Gaslighting in the Store Office, and Home (*T. I. E. S.*, January).
Whimshurst, F. L. Free Maintenance (*J. G. L.*, May 3).
The Automaton Lamplighter (*J. G. L.*, May 3).
Gas at the Japan-British Exhibition (*G. W.*, May 21).
High-Pressure Gas Lighting in Birmingham (*J. G. L.*, May 24).
Rendering Acetylene Headlights Efficacious in Fog (*Acetylene*, May).
Neue Invertbrenner ; Beleuchtung mit flüssigen Leuchtmaterialen (*Z. f. B.*, April 30, May 10).
A Huge Armoury Lighted by Gas (*Am. Gaslight Jour.*, May 16).
Table Lights (*Am Gaslight Jour.*, April 25).
Les Grands Installation d'Acetylene en Amerique (*Rev. des Eclairages*, April 30, May 10).

MISCELLANEOUS.

T. Thorne Baker. Selenium in Phototelegraphy (*Engineering*, April 8).
Coblentz, W. W. The Reflecting Powers of Tantalum, Tungsten and Molybdenum (*Phys. Rev.*, May).
Hammer, W. J. The Selenium Cell (*Elec. Rev.*, N.Y., April 30).
Pirani M. v. Uber die Messung der wahren Temperatur von Metallen (*Verh Deutsch. Phys. Gesell.*, April 15).

The Use of other Illuminants with the Mercury Arc to produce a White Light.

Abstracted from *The Electrical World* of New York, Sept. 23, 1909.

H. E. Ives (*Electr. World,* N.Y., September 23rd, 1909), has investigated the illuminants best fitted, when combined with the mercury vapour lamp, to produce a white light, apparently resembling daylight. Since this lamp is strong in green rays and weak in red, it might be thought that carbon filament incandescent glow-lamps would be best fitted for the purpose. Actually, however, this was not found to be the case, the incandescent mantle and the tungsten lamp being both preferable. In deciding this point the Ives colorimeter was used, a measure of the proportions of light from each of the lamps studied being recorded. In this connexion the author presents the following results :—

It may be observed that the specific consumption of the tungsten mercury combination is 0·8 watts per candle-power, and that of the carbon-mercury combination 1·4 watts per candle-power.

The resemblance of the tungsten-mercury combination with daylight is very close, but the best attainable match was somewhat pinkish. It is pointed out that it is only the *integral* colour which apparently resembles daylight so closely. The combined spectrum consists of a bright line and spectrum superimposed over a continuous one, and therefore the appearance of coloured objects, seen under the combined light may appear very different from that under daylight conditions.

	Red.	Green.	Blue.	Proportion Candle Power to 1 c.p. Mercury Light.
1. Welsbach ($\frac{1}{2}$ per cent. cerium) ...	48·7	38·3	13·0	—
2. ,, ($\frac{3}{4}$,, ,, ...	54·0	37·4	8·6	0·57
3. ,, ($\frac{1}{4}$,, ,, ...	57·5	35·5	7·0	—
4. Tungsten lamp ($1\frac{1}{4}$ w.p.c.)	61·4	31·7	6·9	0·54
5. Tantalum ,, (2 ,, ...	64·6	30·4	5·0	—
6. Carbon ,, (3·1 ,, ...	65·7	29·8	4·5	1·4
7. Mercury ,, ...	24·1	31·4	44·5	—

The
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EDITORIAL.

A Complete Course of Lectures on Illuminating Engineering.

An admirable series of lectures on various aspects of illumination is to take place at the Johns Hopkins University, Baltimore, U.S.A., after the annual convention of the American Illuminating Engineering Society this year. The moment is ripe for its organization. Authorities, both in this country and in the United States, have expressed themselves as strongly in favour of such a course, and the recent discussion of the Illuminating Engineering Society in London also revealed a complete consensus of opinion on this point.

Thirty - six lectures are to be delivered in all. They will be supplemented by laboratory work and practical demonstrations under the supervision of several of the greatest authorities on photometry in the United States. From the account published on p. 447 readers will be in a position to judge for themselves the value of this course. It appears to be unique, both in its wide scope and on account of the standing and number of authorities who will deliver lectures on this occasion. Many of the lecturers are regarded as leading authorities in the United States on the subject with which they will deal, and those who attend this course will certainly have an excellent opportunity, not only of surveying the progress of the whole subject, but also of appreciating the different points of view of various experts. Among these lectures we may mention the series of six lectures by Mr. L. B. Marks (Past-President of the American Illuminating Engineering Society) on 'The Principles and Design of Interior Illumination' and those on 'The Physical Characteristics of Luminous Sources' by Dr. E. P. Hyde, the President for this year; also those of Dr. Steinmetz on 'Electric Illuminants' and Mr. W. Cook (Vice-President of the American Institute of Architects) on 'The Architectural

Aspects of Illuminating Engineering,' &c.

Of special interest, again, are the lectures on the Principles and the Design of Exterior Illumination to be delivered by Dr. Louis Bell, Consulting Engineer to the Edison Electric Supply Co., in Boston, and Mr. E. N. Wrightington of the Boston Consolidated Gas Company, who have both been recently actively engaged in advising the Street-lighting Committee of Boston on the suggested improvements in the Public Lighting of that city.

The idea of organizing this course immediately after the Convention of the Illuminating Engineering Society is a happy one. Probably it would have otherwise been impossible to secure the simultaneous assistance of so many well-known authorities. The scheme is one which deserves emphatic commendation and cordial support.

Considerable progress in the direction of lectures on illumination has undoubtedly been made in this country of recent years, and we have several times referred to the organization of series of lectures on a small scale by enterprising individuals. In passing we may note, as an example, the series which have just been delivered by Prof. J. T. Morris and Prof. Smith at the East London Technical College (these lectures are referred to on p. 464). But we still await a comprehensive course of the nature about to take place in the United States, and we sincerely hope that a similar effort may shortly be made in this country.

Contracts for Street Lighting.

The extremely interesting paper of Mr. Abady which is reproduced in abstract on page 434 is a sign of the times. But a few years ago the idea of a contract for street lighting based upon the provision of sources of light of a specified candle power, or a given illumination of the street, would have been regarded as illusory; but events have marched with rapidity recently, and this idea is now already a familiar one which we may expect to see carried out more extensively in practice shortly. The Institution of Gas Engineers is to be congratulated on having received a paper of such vital importance, which should serve to stimulate public interest in this question.

Having, however, conceded the value of Mr. Abady's work in this respect we nevertheless differ from him on many of the points raised in his paper. Mr. Abady, for reasons which are only briefly summarized, does not advocate the basing of contracts upon the *actual measurement of illumination* in the streets. He prefers, instead, to rely upon measurement of the candle power of the individual sources. Yet it is the actual illumination which is the ultimate concern of street lighting, and, as Mr. Abady himself points out, it is possible to secure widely different results by adopting various heights of the posts, systems of spacing, polar curves of light distribution, &c., even when the candle power of the sources has been definitely decided upon. Consequently a contract based only on candle power would have to be modified considerably according to the local arrangements in these respects, whereas one based on illumination might have a much more general application, and would allow much greater latitude to the contractor in his choice of fixtures, spacing of posts, &c.

Now it need not be supposed that while we in this country have been considering contracts of this nature other countries have been idle. On the contrary, the United States and Germany have both been devoting a great deal of time to the subject, and the Photometrical Committee of the German Institution of Electrical Engineers have this year drawn up a series of recommendations for the testing of

illumination,* according to which it is suggested that measurements of illumination, both for indoor and outdoor lighting, should invariably be made in a horizontal plane at a distance of one metre above the ground. It is anticipated that these recommendations will be adopted provisionally for one year; meantime, they have also been submitted to the German Institution of Gas Engineers for approval. As will be seen from an article summarizing the progress in street lighting on page 442, there seems to be a growing recognition that this method of measurement in a horizontal plane, while certainly not ideal, represents what is, for the present, the best compromise possible under the circumstances.

It may be suggested, therefore, that it would be unwise if totally different systems were adopted in various localities in this country, without regard to what is being done elsewhere, and that it would be much better if we could agree upon a common system of testing which would be accepted by all parties interested. One thing is certain: any system which is to meet with general approval and command respect must be contrived as the result of deliberations of accredited experts, and the other authorities interested, and not as the result of the views of any one individual, however gifted he may be.

We cannot enter very fully into the details of this contract. We might, however, suggest that it would be a preferable method to base the contract on a suitable combination of two systems, namely, to specify the provision of a certain minimum illumination, and, in addition, a minimum energy supply which can be measured.

The contract should be subject to revision at frequent intervals, and advantage should be taken of such opportunities to adopt any improvement in methods of lighting which has been made in the meantime, and which would clearly lead to economies and greater efficiency in the illumination, on the understanding that the resulting profits would be shared between the two parties.

* *Illum. Eng.*, London, June, 1910, page 403.

We also take this opportunity of pointing out once more the need of a *Central Board* to control the lighting of the whole of London. Light, in short, being a public necessity, ought to be treated in the same wide manner as water supply, sewage disposal, traffic regulation, and other public matters which have already been systematised for the whole of London.

There are many other points to which objection might reasonably be taken in the proposed form of contract, but on which restrictions of space prevent our making lengthy comment. It may be said, however, that in an important agreement of this nature there should be no ambiguity, and the phraseology should be clear and definite. Some comments on points of detail which seem to suffer in this respect will be found in the Correspondence Columns of this number (p. 467); to these we invite our readers' attention.

Finally we may add that, taken as a whole, we regard this contract as a valuable precedent. In bringing these criticisms to the notice of our readers our object has been merely to suggest some respects in which it does not seem sufficiently accurate or explicit, and might check progress in the desired direction owing to misunderstandings occurring on details.

Good Illumination in Factories and Workshops.

We have before us the newly-issued Annual Report for 1909 of H.M. Chief Inspector of Factories, Mr. Arthur Whitelegge. In order to do fuller justice to its contents we postpone detailed comment till our next number. On this occasion we only desire to express our great gratification at the prominent place assigned on this occasion to the question of the proper illumination of workshops and factories.

For some time there has been a growing conviction that the lighting conditions in factories and workshops required more careful supervision, and the last few reports of H.M. Chief Inspector have contained an increasing number of references to the subject. Inspectors have continually mentioned instances in their experience of bad conditions of illumination such as must exercise an injurious influence on the health of employees, or, by interfering with their work, lead to needless strain and breakdown. The present report, however, takes up the matter much more fully, and assigns it far greater prominence than has previously been the case.

In the General Report it is pointed out that the earlier Factory Acts are silent as to the adequate lighting of workrooms, and that even the most recently issued recommendations have only treated the subject in a general manner. Nevertheless, the Report goes on to explain, bad lighting has a directly injurious effect on health, safety, and cleanliness, and the neglect of cleanliness which it occasions may considerably add to the risk involved in the handling of poisonous materials. The Report proceeds to give illustrations of the importance of good illumination, both daylight and artificial, and makes special reference to the necessity for proper methods of measurement. Mr. D. R. Wilson, it is stated, is making a special study of this question on behalf of the Home Office, and has already carried out a series of measurements of the illumination in underground bakehouses, &c.

It is very pleasant to note that the Report, in quoting various articles on the subject and summarizing the existing information, makes special reference to assistance derived from *The Illuminating Engineer*. We need hardly say that any service which the Illuminating Engineering Society or this journal can render in this direction will be freely given in the future as in the past. Some credit is certainly due to this journal and to the Society for having persistently called attention to the importance of the subject, and it is a great encouragement for us to observe that these views are now receiving such influential and emphatic support.

The Report proceeds to point out that there is, as yet, a great lack of adequate data regarding the conditions of illumination best suited for various purposes. At present, and for some time to come, a great deal of pioneering work will be necessary, though the accumulated experience of the last few years, and especially the formation of the Illuminating Engineering Societies in this country and in the United States, has already led to a considerable advance in knowledge of the fundamental principles of the subject. We may, however, anticipate that much patient work will be necessary before any very definite recommendations on factory lighting can be made. We feel sure that all those who desire to see this matter dealt with in a broad and scientific manner will commend the intention of the Home Office of feeling their way gradually towards positive conclusions. It is quite enough that the importance of the subject should be realized, and that a steady effort should now be put forth to acquire the needed information and data. Even so, the influence which the department can exercise will be very considerable, and their suggestions would often be highly valued by those in doubt as to the respects in which their lighting arrangements need modification. The truth of the matter is that all parties now concede that the present state of things is unsatisfactory. Their only doubt is to whom they shall look for guidance. Both in the literal and the metaphorical sense, the public demand at the present is for "more light" — and better illumination.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 423) now proceeds to give the results of a series of PRACTICAL MEASUREMENTS OF ILLUMINATION undertaken by himself and Sir William Preece previous to 1892. Some of these refer to street lighting, and the suggestion was put forward at that time that the minimum value permissible should not be less than 0·03 foot-candles. Other data are given relating to the illumination of the South Kensington Museum, and the conditions prevailing in the Charing Cross and Cannon Street Railway Stations at this period, &c.

Dr. B. Monasch (p. 427) concludes his article on the use of METALLIC OXIDE ELECTRODES FOR ARC LAMPS. He summarizes the qualifications of the materials to be used for this purpose and describes a number of methods by which such electrodes can be rendered conducting in the cold state. Finally he gives some particulars of the magnetite and titanium carbide arc lamps, and discusses conditions under which such lamps can compete with high candle-power incandescent glow-lamps for street lighting.

Following this will be found an account of the ANNUAL MEETING of the INSTITUTION OF GAS ENGINEERS (p. 430), in which reference is made to the PRESIDENTIAL ADDRESS delivered on this occasion and the paper on 'PUBLIC LIGHTING FROM THE MUNICIPAL STANDPOINT by **Mr. J. Abady.** An abstract of this paper will be found on p. 434. The author discusses the conditions with which a good contract for street lighting ought to comply, and gives three forms on which specifications might be modelled. The method he favours, however, is that based on the provision of a certain minimum candle-power, and he proceeds to quote, from the contract of the Westminster and City Council, details for the carrying out of periodical photometrical tests to ensure the preservation of this value. The last portion of the paper contains an analysis of the objects of street lighting, the best kind of polar curve for light distribution, and the spacing of lamps, &c. A brief account of the discussion following this paper is also given.

Reference may here be made to a note on the Memorial of Sir George Livesey; an illustration is given of the statue of him by Mr. F. W. Pomeroy which is now on view at Burlington House (p. 433).

The paper on street lighting contracts referred to above is followed by an article in which the views of a number of authorities recently published on STREET LIGHTING AND STREET PHOTOMETRY are summarized (p. 442). It is pointed out that in the majority of cases it seems to be considered that measurements of the actual illumination in a horizontal plane are most desirable, and this system has been recommended by the photometrical committee of the Verband Deutscher Elektrotechniker. It is also suggested that good street lighting consists mainly in a compromise between the production of uniform illumination and the avoidance of glare. Several new types of reflectors, designed to produce the requisite uniformity, are described, and reference is made to a paper by Mr. A. J. Sweet which contains several practical suggestions for limiting glare. Finally, attention is drawn to the possible application of the new Quartz Mercury Vapour Lamp, having an exceptionally low intrinsic brilliancy, to street lighting.

On p. 447 an account is given of the COURSE OF LECTURES ON ILLUMINATING ENGINEERING to be held at the Johns Hopkins University, Baltimore, U.S.A., after the Annual Convention of the American Illuminating Engineering

Society. The course contains thirty-six lectures on different sections of illuminating engineering, all delivered by experts in their respective fields. The course will be supplemented by practical work and demonstrations under the supervision of several of the leading authorities on photometry in the United States.

A paper by **Dr. E. P. Hyde** (p. 450) deals with Radiation Phenomena as Applied to Incandescent Filaments. The author proceeds to discuss several methods of ascertaining whether a high luminous efficiency of a filament is due to selective radiation, or high emissivity, or high temperature ; these methods are based upon an analysis of the relation between the intensity of radiation in different parts of the spectrum of an incandescent material, and its "lumens per watt." Experiments have already been described dealing with tungsten, tantalum, and other materials, and the author has since added data on platinum. This paper is to be continued in a subsequent number. Following (p. 453) will be found a series of Short Notes on Illuminating Engineering compiled from various sources, such as the action of The Local Government Board in Connexion with Street Lighting, the Design of Fixtures, methods of Testing the "Steadiness" of Sources, &c.

On p. 455 is an article by an Engineering Correspondent dealing with the Lighting of the Old South Kensington Museum. It will be recalled that the lighting of the new South Kensington Museum was discussed in the May number of this journal. In the present article the writer contends that the illumination in many quarters is not all that can be desired, and could often be materially improved by installing more up-to-date lamps and fixtures. Illustrations are given showing the route followed by the author when visiting the Museum.

A series of lectures have also been delivered at the East London College by **Prof. J. T. Morris** and **Prof. C. A. M. Smith** respectively (p. 464) dealing with The Illumination of Interiors. The first two lectures dealt with the natural and electric lighting, and the third with petrol-air gas. An account was given of methods of studying the intensity of daylight, the variability of which, though exceedingly great, takes place more gradual than do fluctuations in artificial lighting. To illustrate the latter the lecturer described a series of tests carried out on the underground railways according to which it was shown that the illumination varied very considerably from station to station. Curves were also given showing the effects of light on the pupil aperture of the eye, the influence of glare, and shades and reflectors. In the last series of lectures the qualities of Petrol-Air Gas were dealt with in a general manner, several different plants being exhibited.

Among other articles we may mention that on p. 461, in which a brief account is given of some Tests on Incandescent Mantles and Electric Glow Lamps, including the polar curves of various illuminants. On p. 448 will be found a short note on the use of Acetylene for Emergency Lighting.

It is pointed out how, during the recent floods of Paris, both the gas and electricity supplies were out of order and portable self-contained systems of lighting were found very serviceable.

Portable high candle-power acetylene outfits are also used in connexion with the erection of buildings, &c.

At the end of this number some correspondence is published dealing with the Specifications for Street Lighting described by Mr. J. Abady earlier in this number. It is pointed out that some of the directions in this contract are not sufficiently definite and explicit. For example, it is of little value to specify that a lamp must give a "steady" light and have a white or yellowish white colour, unless some directions are given as to how these qualities are to be tested.

On p. 470 will be found the usual Review of the Technical Press.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Illumination, its Distribution and Measurement.

By A. P. TROTTER.

Electrical Adviser to the Board of Trade.

(*Continued from p. 367, Vol. III.*)

Practical Measurements of Illumination.—The first section of these articles treated of the theory of the distribution on a horizontal plane; the second described photometers for measuring candle-power and photometers for measuring illumination; this third and last part deals with results of some early examples of practical measurements of illumination.

The only records which I have of measurements of illumination made with Sir W. Preece in the "eighties" are a few of the experimental lighting at Wimbledon.* Fig. 123 is probably one of the earliest illumination curves plotted from actual measurements. These were taken on May 21st, 1884. Two Swan lamps on posts 20 ft. high were set 100 ft. apart. The measurements were calculated in foot-candles or metre candles, but are plotted with 100 as an arbitrary maximum.

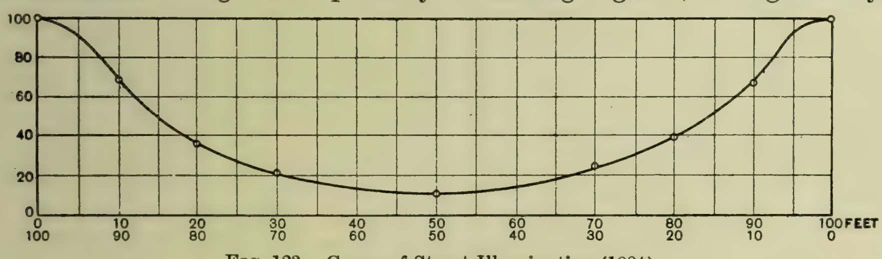

FIG. 123.—Curve of Street Illumination (1884).

The two principal objects of the work which I carried out in London in the winter of 1891–2 were to ascertain the nature of the distribution of illumination in various streets and public places, and the amount of that illumination in foot-candles.

The observed distribution of illumination was found to agree very closely with the general results which might have been arrived at by calculation. This agreement was satisfactory since it afforded a practical confirmation of the theory. Iso-lux curves or contours of equal illuminations based on calculations, such as those of M. Maréchal* are interesting exercises, and make attractive diagrams, but they do not carry much weight with the consulting engineer, borough surveyor, or lighting contractor. On the other hand, three or four dozen good measurements of illumination plotted graphically either as illumination curves or as contours, do not carry full conviction unless it can be recognized that they represent results which can be analyzed by simple calculation. If the engineer who has to specify for or to carry out the illumination of a street or building, examines a few cases of measurements of illumination, or better still if he makes a few tests with an illumination photometer and compares them with the theoretical distribution, just as a

* Report of Mr. W. H. Preece to the Streets Committee of the Honourable the Commissioners of Sewers of the City of London. 1885. See also *The Electrician*, Vol. 14, p. 498.

* *L'Eclairage à Paris.*

civil engineer might study the construction of different types of bridges and compare them with the theory of their design, he will be able to judge intelligently of the two chief factors of practical illumination; first the degree of uniformity which is desirable for a particular case, and how that may be obtained by the best distance between the lamps and their best height from the ground; and second, the candle-power necessary to give the illumination desired.

In 1892 I did not attempt to deduce any definite rules from the results of my measurements, but I stated that 0·03 foot-candle appeared to be the lowest point that should be reached in a well lighted street. In the eighteen years which have elapsed since those measurements were made, the minimum illumination of streets and average speed of the traffic, and perhaps the noise, have increased about three fold.

South Kensington Museum.—I have had some hesitation in re-writing that part of my paper of 1892 which dealt with the result of measurements, but I offer them to my readers partly because they were the first set of extensive measurements of illumination, and partly for the purpose of comparison with the improved lighting of the present day. One of the first examples which I examined was that of South Kensington Museum. The Sculpture Court, containing the Trojan Column was well and sufficiently lighted by Brush arc-lamps placed at the very considerable height of about 50 ft. This Court, which still remains with but little alteration, is 135 ft. by 60 ft., the height of the ceiling is 83 ft. The illumination was quite sufficient for the students, who are to be found there in the evening, sketching architectural and other details. The great size of many of the objects exhibited in this court prevented more than seven or eight lamps being seen from any one position. It was found that the illumination 6 in. from the ground depended at any point simply on the number of arc-lamps in sight at that point. The following readings were taken near the end of 1891 with the 5 in. cube photometer* :—

Foot-candles	0·55	0·5	0·6	0·5	0·8	0·7.
Number of arcs in sight	6	6	7	6	8	7

In the Silversmith's Court the illumination was found to be 2·6 foot-candles with ten arc lamps in sight. In the Japanese Court 1·6 foot-candle with eight lamps in sight; in the Great Hall near the centre, 2·4 foot-candles with nine arc lamps in sight, the lamps being about 25 ft. from the floor. In the Gallery over the Silversmith's Court, near the book-binding cases, about 3·5 foot-candles were recorded. Opposite the refreshment room, in the corridor lighted by glow-lamps, the illumination was found to be 0·65 foot-candle.

In the report on the action of light on water-colours† by Dr. Russell and Capt. Abney, measurements made by General Festing with the Preece Photometer are given. North-east water-colour gallery (gas) 1·81 foot-candle; south-east water-colour gallery (gas) 2·32 foot-candles; Jones Bequest gallery (electric glow-lamps) 1·72 foot-candles; Raphael gallery (arc) 2·26 foot-candles; Sheepshanks gallery (arc) 3·12 foot-candles. The mean natural illumination of daylight measured for the blue rays in one of the galleries during April and May was about 13 foot-candles. On thirteen days it exceeded 20-foot candles, the maximum was about 36.

Charing Cross and Cannon Street Stations.—By permission of Sir Myles Fenton, measurements were made at Charing Cross and Cannon Street Stations. The arc-lamps at Charing Cross were about 18 ft. from the platform. The maximum illumination on the evening of January 29th, 1892. was to be found between 15 and 22 ft, from the point below the lamp, and varied from 0·4 to 0·5 foot-candle. The minimum was about 0·05 foot-candle. There were fourteen arc-lamps in the station, arranged somewhat irregularly in four rows. The station covers about 9,050 square yards. There were, therefore, roughly, 646 square yards to each lamp.

* *Illum. Eng Lond.* Vol. ii., p. 658.
† Blue Book, C. 5453, 1888.

Two sets of measurements were made at Cannon Street Station, one with the 6 in. cube photometer, and another, on the date already mentioned, with the improved form. These measurements agreed fairly well with each other; the first pattern gave low readings for low illuminations, owing to diffused light on the reflecting screen.

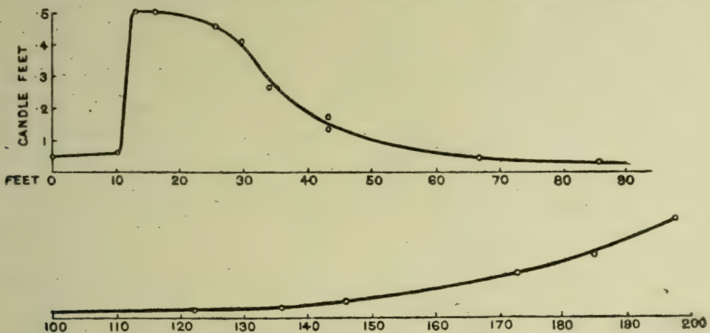

FIG. 124.—Distribution of Illumination at Cannon Street Station (1892).

Fig. 124 shows the distribution of illumination along the main-line arrival platform, starting from the point beneath a lamp enclosed in a lantern of clear glass. There was a deep shadow of 0·05 to 0·06 foot-candle beneath the lamp. All the readings are given as small circles on the curve. The lamps were an old form of the Brockie pattern, and took 15 amperes; they were hung at about 35 ft. from the platform. There were eight lamps, arranged symmetrically. The station covers about 13,900 square yards, giving about 1,740 square yards to each lamp. The minimum was about 0·025, and maximum 0·35 to 0·4 foot-candle, distinctly less than at Charing Cross; but the greater height of the lamps prevented the glare which was to be found at the latter station Assuming the volts of the lamps to be about the same, the watts expended at Charing Cross were about 15 per cent greater than at Cannon Street. The difference in illumination was greater than this; but, owing to the irregular arrangement of the lamps at Charing Cross, an exact comparison could not be effected unless a complete survey of the station had been made. On May 6th, 1910, the maximum illumination on the arrival platform at Cannon Street was 1·65 foot-candle, and the minimum was 0·08.

(*To be continued.*)

Metric System to be used in Papers presented before the Illuminating Engineering Society in the United States.

At the regular meeting of the Council held on June 9th, 1910, it was resolved that wherever practicable, metric equivalents be placed in parentheses after English measures in technical papers presented before the Society. By this means it is hoped to familiarize readers with the use of the metric system and thus facilitate the ultimate adoption of that system.

The Hefner Lamp and the British Candle-Power.

A test has recently been made at the National Physical Laboratory by Mr. C. C. Paterson at the request of Mr. A. P. Trotter, of a Hefner lamp which he bought in 1895. The sighting gauge has been packed up so as to increase the height of the flame by 4mm. After applying Liebenthal's correction for moisture (from 12 litres per cubic metre, at which the test was carried out, to 8 litres, the British normal value), and a small correction for barometer, the value in British candle -power was found to be $0{\cdot}99_5$. This shows that only a simple adjustment is required to convert the intensity of the Hefner lamp into one British candle.

The International Hygienic Exhibition at Dresden.

The attention of our readers may be drawn to the International Exhibition of Hygiene to be held at Dresden from May to October in 1911 when there will be discussions on all matters connected with hygiene and public health accompanied by exhibitions of scientific apparatus and industrial processes connected therewith.

The exhibition has grown out of the conference on public health held in Dresden in 1903. On this occasion an instructive exhibition entitled 'Public Diseases and How to Combat Them' was exceedingly effective in arousing public interest. A subsequent conference of German experts on hygiene was again held in the same city in 1906, and it was then decided to hold an international exhibition of 1911. At this exhibition there are to be a number of different sections devoted respectively to the popular, scientific, histerical, and indusrrial aspects of hygiene; there will also be a special display illustrating the part played by sports in promoting health.

The programme has been divided into twelve main branches which are again subdivided. The first of these deals with air, light, soil, and water, and their influence on health. Under this heading is included the distribution of light, its constitution, and the physical and chemical effects of different parts of the spectrum, diffused sunlight, methods of measuring light, &c.

The subject of illumination will again be considered under Group II. The Chairman of the Committee dealing with this point is Dr. Kruse, Director of the Hygienic Institute and University at Königsberg, while Dr. Bunte of the Technische Hochschule at Karlsruhe, and Dr. Wedding of Charlottenburg, are also giving their support and assistance.

Other matters of public consequence to be discussed include Ventilation and Water Supply, Town Planning, Purity of Food, Hygienic Clothing, Industrial and School Hygiene, &c.

In the introduction setting forth the objects of this Exhibition a note is struck which is in full accordance with the tendency of the day, namely, the desire for concerted action between different nations and professions in order to combat such diseases as tuberculosis and discuss questions affecting social hygiene. The support of societies and institutions in other countries will be welcomed and it is hoped that they will assist the objects of the Exhibition by showing novel scientific apparatus, &c. We hope that, among other services, the Exhibition will serve to stimulate further the growth of interest in the hygienic aspects of illumination.

Mine Rescue Apparatus.

With reference to Mr. Winston Churchill's statement in the House of Commons on Thursday last, "that the time has now arrived when a definite effort should be made to break new ground and set up a higher standard" of safety in mines, we learn that a Committee, appointed by the Council of the Royal Society of Arts, and under the chairmanship of Sir Henry Cunynghame, K.C.B., is now considering the relative merits of a number of life-saving appliances which have been submitted in response to an offer, under the Fothergill Trust, of a gold medal or prize of 20*l*. for the best portable apparatus for enabling men to undertake rescue work in mines or other places where the air is noxious. The Committee of the Society are in communication with the South Midland Coal Owners Mine Rescue Experimental Committee, who are also conducting exhaustive inquiries with a view to discovering the most suitable apparatus for use in the South Midland coalfields.

The Use of Metallic Oxides in Arclamp Electrodes.

By B. Monasch.

(*Concluded from p.* 394.)

IV.

In selecting the metallic oxides used in arclamp electrodes, one has to bear in mind other points besides their properties as producers of light. Such oxides must, in general, have three main qualifications. They must be good light producers, must have a satisfactory electrical conductivity, and must waste away at a sufficiently slow rate. Of the metallic oxides which conduct in the cold state there are some, such as PbO_2, CdO, MnO_2, &c., which can be dismissed at once, for they yield little light and melt at too low a temperature. In these experiments magnetite, both in the form of blocks about the size of one's fist and also in a pulverized form, was found to be a good electrical conductor in a supply P.D. of 110 volts. It is remarkable that Streintz* has included magnetite among the non-conducting oxides. Arclamp electrodes are usually cast in a cylindrical form and one must therefore shape the magnetite accordingly. The simplest method of doing this is to fill an iron tube with magnetite powder or small particles, the iron tube serving merely as a mechanical holder. After the arc has been formed an electrically conducting molten cup is formed on the tip of the electrode. Such metallic oxides as do not conduct in the cold state must somehow be rendered conducting. This can be accomplished by means of the metallic outer tube which serves two distinct purposes, namely, to lead the current to the tip of the electrode and to add to the non-conducting core a certain percentage of conducting material. A cup of molten material of this nature then forms at the tip of the electrode rendering it possible to strike an arc on a 110-volt circuit even in the cold state.

It was in this way that the magnetite electrodes of the General Electric Co., of New York were constructed. One can also achieve the same object by mixing the non-conducting and conducting metallic oxides in the powdered state into a thick paste with some binding material. Out of this paste electrodes are pressed and are subsequently treated by processes similar to those used for carbon electrodes. In the course of such processes the metallic oxides are completely or partially converted into the metallic state so as to give the electrodes a good electrical conductivity. Ladoff* has observed that the more strongly reduced electrodes gave the more light; for this, however, a number of different circumstances, quite apart from the degree of reduction, seems to be responsible.

As shown in Fig. 3 pure titanium oxide appears to be the best producer of light among the materials examined. Yet pure oxides of this nature can only be used in the electrodes when some method of starting the arc is provided. Pure titanium oxide, in a cylindrical iron skin 0·2 mm. in thickness and having a total diameter of 16 mm., forms a molten cup on the electrode tip which on cooling refuses to start an arc on 110 volts. When 220 volts is applied the arc can usually be started but not invariably so, the result depending upon the exact situation of the arc previous toits being extinguished.

It is possible to improve the conductivity of the electrodes by other methods —for example by the addition of suitable metals to the non-conducting metallic oxides. It is, however, essential that the metals should be in a very finely powdered state. Otherwise the arc would from time to time light upon the larger metallic particles and the flame would lose in luminosity and change colour. Some experiments were carried out on this point, metallic powder being added to the powdered titanium in various proportions. Iron alone gives a much less luminous arc

* Drud. Ann. der Physik, 9, p. 885, 1902.

* J. Ladoff, *Electrical World*, 45, p. 757-759, 1905.

than magnetite. Nevertheless it is only by the addition of a considerably higher percentage of iron than of magnetite that the luminous efficiency of titanium oxide is markedly diminished.

Titanium oxide electrodes containing an addition of 10 per cent. of iron will strike an arc in the cold state on 110 volts, while electrodes to which the same percentage of magnetite had been added would not do so. For additions of iron up to 60 per cent. the arc has the characteristic appearance of the titanium oxide ; higher additions render it blue and feebly luminous. All metals are not equally serviceable as a means of increasing electrical conductivity without at the same time unduly diminishing the light. If, for example 10 per cent. by weight of metallic copper powder is added to titanium oxide the candle power of the arc (4 amperes 80 volts) is about 1152 H.K. ; but an arc cannot be struck on a 110-volt supply, and the cup in the cold state has not the same good electrical conductivity as would be secured by the addition of the same percentage of iron. By increasing the added percentage of copper 50 per cent. the cup at the tip of the electrodes could certainly be rendered conducting on a 110-volt supply, even in the cold state, but the intensity of the light under these conditions fell to only 166 H.K. ; moreover with so high a percentage of copper as this frequent changes in the appearance of the arc take place. Sometimes the titanium oxide flame appears, though somewhat reduced in luminosity ; at other times the flame is coloured by the greenish tinge of copper. By the addition of 50 per cent. of aluminium powder the intensity was reduced to about 150 H.K. ; the arc also refused to strike even on 220 volts and with a moderately warmed copper anode. The addition of 50 per cent. of magnesium powder also failed to induce the arc to strike. An addition of 10 per cent. of zinc powder to 90 per cent. of titanium oxide gave a similar result. An addition of 50 per cent. of zinc enabled the arc to be struck, but reduced the intensity of light to only 640 H.K.

Similar results were obtained from a mixture of titanium oxide and powdered metallic tungsten. With an addition of 10 per cent. the arc could not strike on cold electrodes and the light was 1,290 H.K. ; a 50 per cent. addition had the desired effect, but the candle power was now only 420 H.K.

It seems, therefore, that when a cathode composed of a mixture of iron and titanium oxide is used, a stable alloy of titanium-iron which possesses a satisfactory conductivity, is formed on cooling. The strong tendency of iron and titanium to combine in this way is well known ; molten zinc also dissolves titanium.* In general it can, however, be said that a material which serves to increase the conductivity of the cup on which the arc strikes, has also an effect of diminishing the light produced.

V.

On surveying the examples of metallic oxide electrodes which have as yet found application in practice we find the following results.

The General Electric Company in New York have put on the market both a magnetite lamp and a titanium carbide lamp. In the latter lamp the good light producing qualities of titanium are secured. Titanium carbon conducts an electric current, but after burning sometime in air, it becomes covered with a non-conducting layer of titanium oxide, the carbon constituent disappearing as carbon dioxide according to the relation :—

$$TiC + 2O_2 = TiO_2 + CO_2$$

The magnetite lamp is only adapted to continuous current ; the titanium carbide lamp is also serviceable on an alternating supply.

Researches on a magnetite 110-volt lamp (continuous) yielded the following results :—

(1) Current ; 4·2 ampères.

(2.) P.D. cross arc ; 69 volts.

(3) Supply P.D. ; 110 volts.

(4) Power consumption of lamp (arc only) ; 290 watts. [(1) × (2).]

(5) Total consumption of lamp on 110 volts ; 462 watts. [(1) × (3).]

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* W. Huppertz, Versuche über die Herstellung von Titan und Titanlegierungen aus Rutil und Titanaten im elektrischen Ofen, Aachen, 1904.

(6) I. $\smile$ with clear glass globe; 435 H.K.

(7) Watts per H.K. $\smile$ referring to arc alone; 0·666. [(4) ÷ (6).]

(8) Total watts per H.K. $\smile$; 1·06 [(5) ÷ (6).]

(9) Burning hours with cylindrical magnetite cathode 7·5 mm. in diameter and 146 mm. in length; 150 hours.

Very striking is the great difference in the specific consumption (7) and (8), according as the figures are calculated for the arc alone or in terms of a supply P.D. When a number of lamps are run in series, as is often the case in America, we are mainly concerned with the efficiency of an arc itself, and may adopt the figure of 0·666 watts per H.K. $\smile$. In the case of parallel circuits such as are in common use in Europe, of 100–130 volts or 200–250 volts, the magnetite arc is at a disadvantage. Its chief advantage over other lamps lies in the long time it can burn without attention, namely 150 hours. But to-day the magnetite lamp finds it difficult to compete with the high candle-power tungsten lamp under the above conditions. A tungsten lamp yielding 400 H.K. $\smile$ (horizontal) and 1·2 watts per H.K. when equipped with a suitably designed mat white reflector to throw the light downwards, and a clear glass outer globe, will yield 448 H.K. $\smile$, that is 1·07 watts per H.K. $\smile$ as compared with 1·06 watts per H.K. $\smile$ on the part of the magnetite arc lamp. In addition the tungsten lamp will burn for over 1,000 hours while the magnetite arc lamp can only burn 150 hours without requiring attention. Again the tungsten lamp gives a perfectly steady light while that of the magnetite lamp is far from being so. After burning 1,000 hours, the light from the tungsten lamp falls about 5 per cent, while the magnetite lamp, at the end of 150 hours, in spite of provision for ventilation and the removal of fumes, becomes covered with a thick brown deposit of $Fe_2 O_3$, which would give rise to a loss of light to 20–30 per cent. The volume of the iron oxide flakes which dropped into the glass globe in the course of 150 hours was in one case found to amount to 250 c.c. For alternating currents of 100–130 volts magnetite lamps cannot be used while the high candle-power tungsten lamp gives the same results as on a continuous current.

The titanium carbide lamp can be used for both continuous and alternating currents; McKay* gave, for the alternating current lamp, the following figures:

Current, amps.	3	4·5
P.D. across arc, volts	105	105
True watts	245	370
I. $\smile$ in clear globe (candles)	625	1,154
Burning hours	75	50
Watts per candle	0·392	0·32

The figures for the specific consumption are in themselves very favourable, but these lamps also really only come into consideration when the series system customary in America can be employed. If a single lamp is to be run on 110 volts it cannot receive more than about 60–70 volts if a reasonably good arc is desirable. The reason why this should be so has been given in the theory of the stability of arcs developed by Steinmetz† and Blondel. The titanium carbide arc, as the diagram of Weedon‡ showed, must be very short, only about 6–8 mm. long, while the titanium arc proper taking 105 volts and 3 ampères has a length of 20 mm. It must therefore give a considerably lower intensity, and on parallel circuits such as are generally used in Europe, could not compete with other sources now in common use for illumination.

* McKay, *Electrical World*, 54, p. 309, 1909.

† C. P. Steinmetz, *Trans.* of the International Electrical Congress, St. Louis, 1904, Vol. II., p. 710, "The Electric Arc."

‡ W. S. Weedon, *The Electrician* (Lond.), 64, p. 556, 1910.

The Annual Meeting of the Institution of Gas Engineers.

THE Annual Meeting of the Institution of Gas Engineers took place from June 14th to June 16th, at house of the Institution of Mechanical Engineers (London), the President, Mr. J. W. Helps, being in the chair.

As usual there were present a large proportion of members from the provinces. The meetings were well attended, and the proceedings were followed with close attention in spite of the sultry weather. In his opening remarks the president briefly alluded to the loss suffered by the nation by the death of King Edward, and a formal resolution was passed to this effect. Subsequently the gold medal of the Institution was presented to Mr. J. Ferguson Bell for his paper on 'Carbonizing,' while silver and bronze medals were presented to Dr. R. Lessing and Mr. R. Watson respectively for their papers on 'Carbonization in Chamber Settings,' and 'Some Advantages and Disadvantages of a Hot Coke Conveyor.'

Among the visitors on this occasion were Mr. P. C. Holmes Hunt, President of the Victorian Gas Association and Mr. Charles Nettleton and Mr. Hermann Burgi from the United States.

PRESIDENTIAL ADDRESS.

In his introductory remarks the President pointed out how the conditions under which the gas industry worked to-day were constantly changing. There was now a tendency to bestow much more attention on how best to dispose of the gas produced, whereas, in the past, engineers had been mainly concerned with the difficulties of generation. This was especially true as regards lighting, which was assuming a prominent position in the minds of engineers of to-day. Companies were now feeling more and more the necessity of cultivating the good will of the consumer and taking a direct interest in the way he used the gas at his disposal. He thought that in the future it would come to be recognized that the maintenance of incandescent burners and mantles was one of the duties of the gas company, who were bound to see that their consumer received satisfaction in this respect. This, of course, involved extra labour and expense, but it might often be found a better plan, in the long run, to spend money in this way in preference to taking a penny off the cost of gas. In this connexion the President pointed out the importance of the Distribution Department of a gas company. At present gas fitters were very often not sufficiently qualified, and it was satisfactory to see that the Gas Light and Coke Company and others were arranging courses of instruction for their benefit.

Another matter which naturally received notice in the presidential address was the vexed question of the relative values of tests of calorific and illuminating power. The President himself (though he admitted that the question was rather a delicate one at the present moment), looked forward to a time when Parliament would eventually decide to abolish an illuminating power standard altogether, and substitute a calorific one. On the other hand the retention of both tests would be a serious inconvenience to the industry.

Mr. Helps then went on to deal with a number of technical matters in connexion with gas generation, and described in some detail the plant at Croydon. Reverting to general matters he urged upon those present the need for combination and concerted action on the part of representatives of different sections of the gas industry. Efforts were specially needed in connexion with publication work. It must also be recognized that the Institution of Gas Engineers, as at present constituted, was open only to a certain section of those interested in the welfare of the gas

industry; seeing that its discussions often dealt with matters of a more or less commercial and financial character it had been urged that those best able to speak from this standpoint should also be admitted to membership. There were, of course, a number of commercial sections and affiliated associations in existence, but he thought it would be more beneficial to enlarge the constitution of the Institution, and to give the body a more general name, such as "The Gas Institute."

A vote of thanks to the President was moved by Mr. Corbet Woodall, and seconded by Mr. J. West, and a resolution was also passed approving the proposal that the Council should appoint a committee to consider the suggestions contained in the address and to report thereon.

Public Lighting from the Municipal Standpoint.

The next item in the proceedings was the paper on 'Public Lighting from a Municipal Point of View,' by Mr. J. Abady, which is abstracted on p. 434 in this number. The institution may be congratulated on having received a paper at this year's meeting dealing mainly with gas lighting and illumination rather than with technical problems connected with manufacture. It must, however, be admitted that much of the discussion on the paper strayed into the familiar paths of denunciation of municipal trading, and, in particular, municipalities undertaking electrical supply. Comparatively few of the speakers dealt in any detail with the photometrical and technical questions raised in the paper.

An interesting comment on the title of the paper came from Mr. C. Botley, who pointed out that it was open to two interpretations, namely, as representing the views of Mr. J. Abady or as the general view of municipal authorities.

Mr. F. W. Goodenough advocated the use of small lamps at frequent intervals. He added that light was chiefly needed in a plane 3 to 4 feet above the ground, while the space within a height of 8 feet above the ground practically represented the area over which light was really needed for practical purposes. It was also to be noted that even Mr. Goodenough, though representing the Gas, Light, and Coke Co., was not averse from admitting that until a given contract, made on the lines suggested by Mr. Abady, had expired, the party which benefitted directly by any improvement in efficiency would be the gas company, or the contractor, and not the municipality.

Mr. C. E. Jones pointed out the advance since the days when a gas company cared little about the light produced, and preferred the kind of burner which consumed most gas. Since that time the subject of street lighting had been raised to a higher level. Mr. Jones proceeded to refer to Mr. Abady as a stalwart to whom the gas industry were highly indebted, and who had done extremely well for gas and Westminster. He added that he believed in time gas would be eventually distributed at a much higher pressure than at present. Mr. H. E. Copp also testified to the value of small units at frequent intervals, with a view to reducing glare. Nevertheless, the provision of very powerful lights was sometimes necessary as a sop to the general public, which seemed still to prefer glare to illumination. Mr. T. Canning appeared to think that the principles of photometry, as laid down by Mr. Abady, applied to gas lamps, but not to electric sources, and that although both lamps might have the same intensity at the source, the electric arc and incandescent filament "did not seem to be diffusive."

Mr. Abady in his reply suggested that this impression might be due to the effect of fog. He did not agree with Mr. Copp that one ought to give way to the popular desire for glare. He was glad that he and Mr. Goodenough agreed as to the value of small units at frequent intervals. With regard to the question of where light was most wanted, he had not taken the light at the ground. He had "taken the light at the source and divided by the square of its distance from the ground!" in testing: this

was a quantity apart from the actual illumination.

Other Papers, &c.

Subsequently special reports of the Committee on the Gas Heating Researches and Carbonization Committee were presented. Several other papers were also dealt with on this occasion, including that of Mr. J. B. Klumpp on 'Gas Calorimetry in the United States' (communicated), Mr. F. J. Ward on 'The Management of Small Gas Undertakings,' and Mr. S. Y. Shoubridge on 'The De Brower Stoking Machinery and Coke Handling Plant.'

Memorial of Sir George Livesey.

We would not willingly let the foregoing account of the *Proceedings* at the Annual Meeting of the Institution of Gas Engineers pass without a reference to the great leader who passed away last year—Sir George Livesey.

It will be recalled that a scheme was put on foot to found a Livesey Memorial Fund, to be devoted to founding a Chair at Leeds University. A meeting of the subscribers to the fund was recently held, under the Presidency of Mr. J. W. Helps, who reported that £10,700 had been contributed to the fund. The chair is to be known as "The Livesey Professorship of Coal Gas and Fuel Industries," and Dr. W. A. Bone, whose work on combustion is well known, will be the first "Livesey Professor."

The illustration on the opposite page, for which we are indebted to the courtesy of the editor of *The Copartnership Journal*, represents a view of Mr. F. W. Pomeroy's statue now on view at Burlington House. An illustration of this size, excellent as it is, no doubt cannot be expected to do more than give a general idea of the appearance of the statue. But we think that those who knew Sir George Livesey will agree that the sculptor has been singularly happy in preserving the steadfast determination, the uprightness and nobility of character, observable in all he said and did.

Iron and Steel Institute.

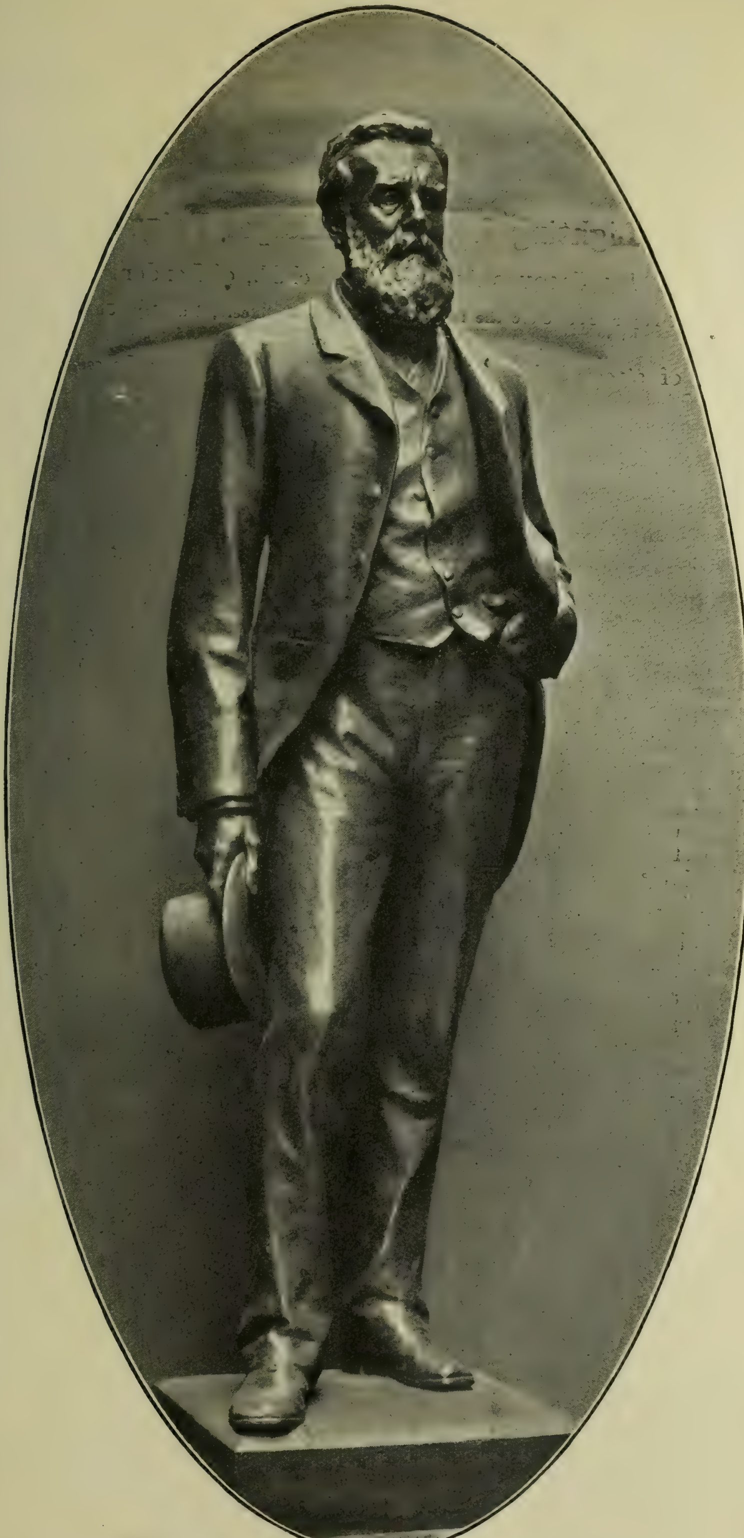
Buxton Meeting, Sept. 26–30, 1910.

We note that, as previously announced, the Autumn meeting of this Institution will be held at Buxton on the above dates. An influential Reception Committee has been formed, the Duke of Devonshire being the Chairman, and Sir A. S. Haslam the Vice-Chairman. The programme is an attractive one, including receptions, conversaziones, and concerts. Visits will also be paid to the works of the Midland Railway Co. at Derby, the Royal Crown Porcelain Works, and the Crewe works of the London and North-Western Railway Co., &c., and opportunities will be presented for the reading and discussion of a number of papers.

The Junior Institution of Engineers: Summer Meeting.

The Summer Meeting of the above Institution is to take place in Dublin and Belfast from July 16th to 23rd. The programme will open with a reception at Trinity College. Subsequently a number of interesting visits will be paid to the Dublin United Tramways Co., Messrs. Guinness's Brewery, The Drainage and Outfall Arrangements in Dublin Bay, &c., and the visitors will be entertained by the Institution of Civil Engineers and the Engineering and Scientific Association of Ireland.

The party will then proceed to Belfast, where they will be received and entertained by the Lord Mayor, and will visit the Belfast Ropeworks, the Ship Building and Engineering Works of Messrs. Harland & Wolff, and other places of interest. The Summer Dinner of the Institution will also take place on this occasion, when it is hoped that the President, Engineer Vice-Admiral Oram, C.B., will be in the chair.



STATUE OF SIR GEORGE LIVESEY.

Public Lighting from a Municipal Point of View.

BY JACQUES ABADY, M.I.Mech.E., of London.

(Abstract of Paper read before the Institution of Gas Engineers, Tuesday, June 14th, 1910.)

THE subject of street lighting presents special difficulties on account of the many diverging interests involved. Thus the municipality has to consider the question of cost while those supplying the illuminating apparatus regard public lighting as an advertisement and therefore desire to have the latest methods installed. It will, therefore, be more profitable to examine the following different forms of street lighting contracts which are in vogue, and to which members have all at some time or another had their attention very forcibly directed :—

A. The contract for supply of energy with maintenance, payment being made for so much energy and not for so much light.

B. The contract for supply of energy only, maintenance being undertaken by a contractor acting for the Municipality or the Municipal Public Lighting Department itself.

C. The contract for supply of light, payment being made for so much light irrespective of the energy required to produce it.

What are the relative merits of these forms of contracts and how do they assure the following desiderata :—

(1) The due observance of the terms of the contract entered into.

(2) The efficient maintenance of the standard of lighting contemplated by both parties when the contract was entered into.

(3) The facility or encouragement for either party to take advantage, during the contract period, of the introduction of improved methods, to either reduce the cost of producing the light, or obtain a greater light for the same cost.

Let us now proceed to examine the alternative forms of contract stated under A, B, and C.

CONTRACT A.—*For the supply of and payment by energy—maintenance being undertaken by the contractor for energy.*

The due observance of the terms of this contract naturally hinges upon the facility for measuring the energy supplied. This involves a number of difficulties. For example, a test of a single lamp is no criterion that the whole system is satisfactory nor that the ideal pressure is generally maintained. On the other hand the introduction of governors is apt to hamper one's efforts towards securing the most perfect efficiency of burning. The further method of fixing the basis of payment is either by an average-meter system or by tests of consumption *in situ ;* and as to these I think the former is unsatisfactory because it naturally induces a tendency to excessive consumption of gas, and does not ensure a community of interest, while the latter, the *in situ* method, is one which presents very considerable difficulty in carrying it out.

The second point is the efficient maintenance of the standard of lighting under the contract. In the case of a gas-lighting contract, the gas company, be it remembered, is maintaining ; and it therefore rests with the company to see that glasses and lanterns are kept clean, that burners are free from dust, and that mantles are replaced when required. So that, assuming *bona fides* and willingness on the part of the gas company, there is nothing in this form of contract to prevent the standard of lighting being maintained. But looked at from the municipal side of the table, there would be a considerable difficulty, in the case of a careless or unwilling gas management, in ensuring that the condition of the public lights shall always be satisfactory.

The third point is an exceedingly important one, and I think this form

of contract is particularly weak in this respect.

Now if a gas company approached the municipality with a proposal to be allowed to substitute an improved burner and pay for the capital cost by the saving in gas to be effected, what is the probable reply of the municipality? Surely it would be in nine case out of ten that if a smaller amount of gas is to be consumed, a porportionate reduction must be made in the lighting bill. In other words, the municipality would no doubt overlook the fact that improvements in light will probably be effected in the future by a decreased consumption and an increased pressure. Where, therefore, is the incentive to a gas company to reduce its revenue from consumption, and bear the additional capital cost for new burners?

If it is an electricity contract, and we substitute "carbon filament lamps" for "4 feet per hour" and "metallic filament lamps" for "3 feet per hour," is there not a similar situation created, and would not the same causes operate to prevent improvement, through replacing carbon lamps by metal lamps or carbon arcs by flame arcs?

Contract B.—*For the supply of and payment by energy, maintenance being undertaken by a separate contractor acting for the municipality, or by the municipal public lighting department itself.*

According to this contract the municipality (whether it maintains by itself or through a separate contractor) has greater control over the efficiency, but the interests of the contractor for the energy are very much at its mercy. Thus if the maintenance contractor neglects the maintenance, the energy contractor suffers; while if the municipal lighting department (taking as it often does the energy from another municipal department which is in competition with a competitive form of lighting) is interested in doing what it can for its sister department, it is plain that the competitive form of lighting suffers, and real competition is at an end.

Provided the contract does not limit the pressure of the gas supply, the municipality can obviously, if it chooses to pay for them, instal improved burners and give its public a better light, without affecting the contractor's position in the least. What it cannot do, however, is to give the same light by the introduction of improved burners, and reduce the cost of gas or electricity, and so reduce the cost to the public of its lighting bill. Of course, if there were simply an agreement to pay for what total energy is consumed without specifying so much energy per lamp, then such reduction could be made, and the municipality has an absolutely free hand. But then the difficulties of measuring the total energy are very great, and I know of no instance in which the payment for total energy is made in this way.

It also seems to me that a direction in which future improvements in the efficiency of gas lighting are to be found will be in a reduction of the quality of the gas, and an increase in the pressure at which it is supplied, so that by reducing on the one hand the amount of air theoretically required for perfect combustion, and increasing on the other hand the mechanical means by which the theroetical amount of air is obtained in practice, we shall be enabled to burn the right quality of gas under conditions of absolute maximum efficiency. It will be seen that contracts A and B specifying as they do either (or both) consumption, pressure, and quality, prevent improvements in the direction suggested.

Contract C.—*For supply of light, payment being made for so much light irrespective of the energy required to produce it.*

The question as to control over the proper fulfilment of this class of contract is one about which there is undoubtedly considerable difference of opinion, and plenty of room for discussion; and, in order that there may be something concrete to discuss, in an appendix are set out the salient clauses of the contract for lighting entered into by the Westminster City Council. The testing clause is one to which attention is particularly directed, because this

is the centre of gravity, as it were, of a contract which is for the supply of so much light. I am not personally responsible for the drafting of the clause, and frankly admit that there are many afternative methods of framing a clause to a similar effect. I append one hereto as follows :—

Each lamp is to be fitted with burners, mantles, globes, and fittings, as the case may be, giving a minimum of ——— standard candle-power, respectively, as directly measured by the council's portable photometric apparatus placed at an agreed distance above ground level, and is to burn ——— hours per annum in accordance with a daily schedule to be hereafter supplied by the Council. The fittings and lamp must be in every respect to the satisfaction of the city engineer ; and in particular the reflectors above are not to be shaped so as to concentrate the illumination at the foot of the lamps, but horizontally flat or slightly convex or otherwise as may be approved by the city engineer, so as to disperse the rays. The tests will be taken in such a manner as to ensure that the glazing bars shall not interfere with the results obtained.

The candle-power shall be arrived at by taking the average of two sets of readings in any position with regard to the light under test—one set at an angle of 20°, and a second set at an angle of 50° to the horizontal. The photometer used shall be one working on the law of inverse squares, and so constructed as to read accurately whatever the respective colours of the light under test and standard light.

Not less than three and not more than six readings, at regular intervals of not less than 30 or more than 60 seconds, shall be made at each angle ; and the average of the readings shall be termed the reading or illuminating power at that angle. If, upon a test being made, the illuminating power of any lamp falls below the prescribed standard and is not more than 10 per cent below it, a test may be made of each of the two nearest lights ; and if the aggregate of the light from the three lamps equals the aggregate required by the contract, no damages shall be recoverable. The tests only to be made in reasonably clear weather —not during rain, mist, or fog—and in the presence of a representative of the contractor should he so desire.

The intention of this contract is that the contractor shall assure himself, by continued test and inspection, that the lamps he provides are, during lighting hours, fulfilling in all respects the requirements of this contract ; and he shall not claim relief from the conditions of this contract on the grounds of non-notification on the part of the Council of any failure to comply with the terms of this specification.

The light given shall be of a steady, invariable character, of a white or yellowish-white colour.

It must be recognized that to select any particular angles favouring one form of light would be most unfair. It will also be recognized that to take the mean hemispherical candle-power is not practicable, as the comparison involves readings at each angle from 90° to 0°, which is impossible with a test *in situ*, besides being a tedious matter.

It will further be recognized by those who have studied street-lighting problems that to include in such a photometrical test either of the angles of 80°, 70°, or 60° would be highly undesirable, because it is at these angles (*i.e.*, in the vicinity of the lamp-post) that one usually gets an excess of light to the detriment of the rays thrown upon the area more distant from the lamp, and their inclusion would encourage, instead of discourage, the distribution of a large volume of light near the post. Now it so happens that if the lighting curves of all types of lamp are examined—electric and gas, arcs, filament, upright and inverted mantles (high and low pressure)—it will be found that in the majority of cases the mean of the light given at 20° and 50° practically coincides with the mean hemispherical intensity, and therefore represents the value as candle-power, (a number of polar curves of different illuminants giving the results over this angular range are shown in Figs. 1 and 2). Of course, it might be possible for an enterprising individual to make a lamp giving 180 candles at 50° and none elsewhere ; and this would be a 90-candle lamp. But a lamp such as this would not comply with the general specification of the Westminster testing clause.

I emphasize the fact, before leaving this point, that there is no question of the light being defined by a foot-

candle test: for one must admit that, had this been done, there would have been introduced all kinds of difficulties and problems (as to the behaviour of light rays with respect to surfaces and view point), about which photometrists themselves are not agreed. The test specified involves simply the light of the lamp itself and the photometer.

The remaining question then is whether it is possible to test in such a manner as to remove all grounds for ambiguity and dispute. As a photometrist, I naturally see no difficulty at all in the matter. But it is possible that those who are not photometrists will look upon a photometer as a very indefinite and indifferent foot-rule indeed; and, of course, it must be admitted that it is necessary to define the kind of instrument and the way it shall be used, in the clearest possible manner. It appears to be quite satisfactory to take an instrument based upon the law of inverse squares, and in which such means of obviating reading errors—due to either colour difficulty or stray light—are provided, as may be agreed upon between the parties entering into the contract. It is also quite simple to agree upon a definite primary standard of light; and it is equally simple to agree upon the secondary standard. This being the case, and it seems that these are all points which are demonstrable, what safeguards against error or chances of dispute should there be provided?

I think these are three—viz., (1) A definition of the weather in which official tests are permissible; (2) absence of infliction of damages if the two lamps nearest to a defective lamp are giving such light as will bring the average of the three up to standard; and (3) the presence of a contractor's representative should be permitted during any test.

It must be admitted as a weak point in this form of contract that, because one or a dozen or twenty lamps are tested and found to be giving the specified light, this is no guarantee that several hundred or thousand lamps will be doing the same thing. On the other hand, there is no limit to the number of lamps which the corporation can test daily if they wish; and further than this the contractor would never know where tests would be made on any night. Upon the question of the practicability, in working, of such a test clause, it might be pointed out that in Westminster we have had five years' experience with a gas and electric light contract; and I am not

CANDLES.

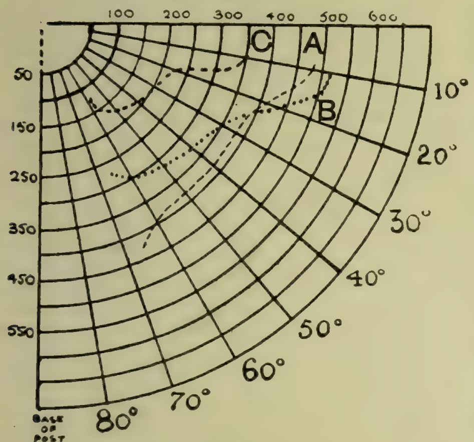


FIG. 1.

A—Three Metallic Filaments in Lantern: 387 Candles.
B—Three Inverted Burners in Lantern: 368 Candles.
C—Two Metallic Filaments in Lantern: 201 Candles.

CANDLES.

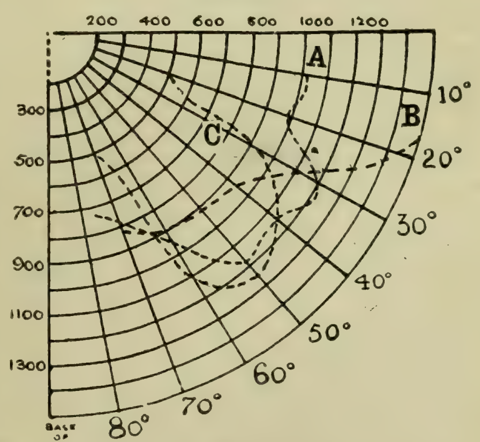


FIG. 2.

A—Three High-Pressure Burners (small) in Lantern: 960 Candles.
B—High-Pressure Upright Burner in Lantern 1193 Candles.
C—Ten Ampere Open Arc: 1000 Candles.

aware of a single dispute, although defects have been found, charged, and paid for.

It is unnecessary to labour the point that this contract ensures—so far as any contract can—"the efficient maintenance of the standard of lighting contemplated by both parties when the contract was entered into."

Does the contract also facilitate or encourage the adoption by either party of improved methods ? It seems to me that it does, because if the contractor finds he can produce the same light at a cheaper cost, or a better light for the same cost, he would surely approach the corporation and offer to share the benefit of such improvement ; and it would be imagined that there are very few municipalities in which the officials or elected members are so neglectful of the public interest as not to take advantage of such an opportunity.

Whatever arrangement, however, may exist in a town between suppliers of light and the local authority as to the contractual basis of the public lighting, it is plain that, from a municipal point of view, the selection of suitable units, the proper arrangement of them, and the general distribution of light are also questions of the utmost importance. And yet, if one may judge from specimens of street lighting, it is evident that these questions are very imperfectly understood ; and in place of scientific arrangement of lamps of candle powers suited to the financial ability of a town, one often sees a motley and haphazard positioning of lamps, of all descriptions—exhibiting the crudest and most harmful contrasts of strong glaring light on one spot and next to none in another.

It is unnecessary to dwell upon the fact that what one town can afford in the way of lighting another town cannot. Thus Westminster's lighting bill is over 40,000*l*. per annum, but then Westminster has a rateable value of about 6,500,000*l*. ; and if this is contrasted with the rateable value of various towns in England, it will be seen that there are not more than three with over 2,000,000*l*., nor more than twenty over 1,000,000*l*. That is, however, no reason why adequate and scientific light distribution should not be urged upon those responsible for the government of towns, large and small ; and therefore a subject well worthy of discussion is comprised in the question, "What is adequate lighting ?"

I am well aware that in many instances—too many instances—the suppliers of light have little or no voice in the selection of positions for lamps or the general drafting of lighting schemes ; and it seems to me that this fact makes it all the more important that, by a clear grasp of the principles underlying the scientific arrangement of street-lighting units, they should be in a position to offer criticism to lighting schemes which are open to criticism, and thereby gradually effect an improvement in public lighting on sound and rational lines.

Now the first point to be thoroughly grasped is that if one has a lamp of a certain candle power, the distribution of the light in the area affected by such a lamp will vary enormously—getting less and less as one gets more distant from the source of light. This variation in distribution depends upon two factors : Firstly the distance from ground level at which the light is placed; and, secondly, the proportion of light emitted at different angles. If the first is known, the radius in which the light at each angle falls can be easily ascertained ; and if the second is known, the actual value of the light when it reaches this radius at ground level can be ascertained just as easily. Light, as is well known, diminishes as the square of the distance from the source, and the distance from the source to the ground at different angles differs greatly with each angle—getting more and more as the angle of depression from the horizontal gets less and less.

It is a mistake to think that, in order to make the light stronger at the distant points, all that is needed is to increase the candle-power of the source. Naturally, this does increase the light at the distant points ; but it also increases the light round the column in the same proportion, and if carried to its extreme (as it often is), this course only results in a glare of light round

the column, which glare, by reason of the contrasts it introduces, makes the disproportion apparently worse. Everyone knows the effect of going out of the sunlight into a darkened room—how at first one cannot see at all, and how after the eye has lost the effect of the sun's glare the vision accommodates itself to the feeble light of the dim room. That is just the effect which the eye encounters in walking along a street lighted in this manner; and it is an astonishing thing that this practice is followed to the extent that it is. Thus, through want of a little thought and the application of simple rules, street lighting in many cases degenerates into a haphazard scheme of point lighting, instead of being, as it should be, the even and uniform distribution of artificial light.

The more attention is drawn to it, the more will this disproportion of light diffusion and the unevenness of distribution probably be noticed, and it is hoped in course of time remedied. The question is, what can be done to improve this state of things, even though the standard set up for attainment is ideal? It appears to me that there are two ways. The first way is to select lamps with lighting curves which are greater at 10° than at 15°, greater at 15° than at 20°, and which get less and less as they approach the 80° angle. To do this involves the use of dioptric arrangements or reflectors, and, of course, the disproportion can at best only be partially remedied.

Failing, however, the possibility of making lamps with such a polar curve as will compensate for this disproportionate distribution curve, it appears to me that the only method of producing anything approaching even lighting is to bring the lighting units closer together, and that it is no remedy to increase the powers of the units on each column. For if this is done, while it increases the light generally, it utterly fails to alter the relative distribution; and, indeed, by inducing a glaring effect at each column, it only serves to increase the contrast and make the lighting effect worse. It is obvious, then, that if one brings the columns closer together, the lighting effect at its weakest point will be reinforced and the unevenness of the distribution diminished. It will also be possible to reduce the candle-power of the sources of light, because there is always an excess of light near the column on account of the initial candle power necessary to give enough light at the distant points. I, therefore, urge attention to this view—viz., the desirability of decreasing the initial candle power of light units and placing them closer together.

In conclusion, it must be recognized that it is very difficult indeed to lay down any standard of lighting, and to say what lighting is suitable for a particular street. In all cases, naturally, positions have to be varied to coincide with street corners and to give greater light at crossings, &c., while the demands of a business street with heavy traffic will naturally not be the same as those of a residential street. Nor even if the demand were made or put forward in competition would the same type of light suit all streets. Thus, high unit lights on tall columns would be most suitable for a residential street, because the direct light produced at the level of bedroom windows is not to be desired. All one can do is to point out what effect, with respect to evenness of distribution, will be produced by various combinations of heights and distances.

APPENDIX.

(At this point Mr. Abady reproduces the recently executed Calcutta Corporation Contract, drawn up by the technical adviser to the Council, Mr. Alfred Mansfield, and entered into between the municipality and the Oriental Gas Company. This is cited as an example of a contract of the B type in which the company supplies energy and the municipality maintains.)

The following is an extract from the Westminster City Street Lighting Contract:—

Extract from the Westminster City Street Lighting Contract.

Specification of Lighting.

See General Conditions of Contract attached.

1. The subject matter of the contract

is the lighting of all or any of the districts in the City of Westminster mentioned in the annexed form of tender and defined on the annexed plan.

The contract so far as it relates to "Installation" includes the provision of any necessary mains, wires, shades, apparatus, lamps, burners, governors, cut-outs, switches, resistances, reflectors, and other fittings necessary for the satisfactory installation of a satisfactory system of lighting of the type quoted for and the execution of all incidental works of every kind, including the cost of the making good of any pavement disturbed, which last mentioned work will be carried out at cost price by the Council at the cost of the contractor.

The contract so far as it relates to "Maintenance" includes the provision of the illuminant, and the cleansing, lighting, and extinguishing of the lamps, the provision of any carbons, mantles, or any other fittings of any kind to ensure the same burning efficiently, and all repairs necessary to the things provided for in the "Installation" contract from whatever cause arising.

The illuminant shall be of the minimum specified candle power.

The period of the commencement of the contract so far as it relates to maintenance is the day following the expiration of the existing contract relating to the district in question. Particulars of the dates of expiration of the existing contracts are given in the annexed "schedule of lights as at present existing in the four districts." The Installation works must previously be completed in accordance with Clause 18 of the annexed "Conditions of Contract."

2. The contractor shall provide all materials, labour, tools, tackle, implements, plant, water, and other necessary things for the proper execution of the works. All the materials used shall be the best of their respective kinds, and applied in the most workmanlike and substantial manner possible, and the work shall be executed to the entire satisfaction of the City Engineer, who shall have full power to reject any materials which he may consider unfit to be used in the work.

3. In the case of "large units" the lamps are to be erected on suitable and approved columns of such a height that the centre of light shall not be less than 20 feet above the adjacent surface of the ground. In the case of "small units" the centre of light shall be not less than 12 feet from the adjacent ground surface.

4. The design of electric lamp pillars is subject to the approval of the Council, and such pillars must be of cast iron or cast iron and steel tube construction. The approved type of gas-lamp columns is that recently erected in Whitehall and Parliament Street. In the case of electric lamps, provision must be made for the winding gear to the footway columns. Arc lamps shall be fitted with automatic substitutional resistances, so that the failure of one lamp will not interfere with others in the same group.

5. Each lamp is to be fitted with burners, mantles, globes, and fittings, as the case may be, giving a minimum of 90, 180, 1,800, or 3,000 standard candle-power, respectively, as directly measured by the Council's portable photometric apparatus placed at ground level, and is to burn 3,940 hours per annum in accordance with a daily schedule to be hereafter supplied by the Council. The fittings and lamp must be in every respect to the satisfaction of the City Engineer, and in particular the reflectors above the light are not to be concave to the light to as to concentrate the illumination at the foot of the lamps, but horizontally, flat, or slightly convex as approved by the City Engineer so as to disperse the rays. The tests will be taken in such a manner as to ensure that glazing bars shall not interfere with the results obtained. The candle-power shall be arrived at by taking the average of two readings in any position with regard to the light under test one reading at an angle of 20 degrees and a second reading at an angle of 50 degrees to the horizontal. A test standard unit of 1-foot candle or of any size in excess of this up to 10-foot candles may be used according to the

character of the photometer with which the tests are made and the class of lamp being tested, all as the City Engineer shall direct. The photometer shall be of the Simmance-Abady Flicker type, or of any type approved by the City Engineer. The intention of this contract is that the Contractor shall assure himself by continued test and inspection that the lamps he provides are during lighting hours fulfilling in all respects the requirements of this contract, and he shall not claim relief from the conditions of this contract on the grounds of non-notification on the part of the Council of any failure to comply with the terms of this specification. The light given shall be of a steady, invariable character, of a white or yellowish-white colour.

6. The whole of the metal work of the lamps shall be cleaned down and painted once in every two years with two coats of oil paint, the last coat being mixed with hard-drying outside varnish, of the special shades of colour generally used by the Council for lamps and as required by the City Engineer, after thoroughly scraping and cleaning. All old paint shall be completely burnt off once in every four years, when three coats of paint, as before mentioned, shall be applied instead of two coats. The painting shall be done at such time of the year as shall be approved by the Council. The glass shall at all times be kept thoroughly clean.

7. The whole of the installation is to be complete and in thorough working order by the time specified in Clause 18 of the annexed Conditions of Contract.

8. Such of the existing pillars and lamps as are the property of the Council may be used in their present positions, free of cost, subject to adaptation as particularized in Tender Form, if they can be adapted in such a manner as to have the approval of the Council. In case any new lamps or parts thereof are required under any scheme submitted by any tenderer, the existing lamps shall be carefully taken down and if the proprety of the Council, shall become the property of the Contractor, who shall make allowance for the value of the same in his tender. The existing mains, surface boxes, &c., are *not* the property of the Council. Possession of the existing lamps, columns, &c., will be given at various dates prior to the end of the year 1910.

Lighting a Rifle Range.

An interesting problem in illuminating engineering was referred to by Mr. G. N. Stickney in a recent article on factory lighting in *The Electrical Review* of New York. Adjoining the works of a leading rifle manufacturer was a 220 yards testing range on which experiments were constantly being made with new models, and it was found to be rarely possible to get satisfactory results on this range with artificial light. On examination the intensity of artificial illumination on the targets proved to be about 6 to 8 foot-candles, This might have been considered ample for many ordinary requirements, but it was not so in this case. The daylight illumination, on the other hand, though naturally varying from day to day, was usually in the neighbourhood of 60 to 70 foot-candles. Eventually an improved system of artificial illumination giving about 30-foot candles was introduced. This proved entirely satisfactory, and later it was decided to use artificial light always, as by so doing an invariable and steady illumination could be relied upon—a matter of some consequence, as tests on different days ought to be comparable one with another.

This is a striking example of the truth that it is impossible to specify a certain order of illumination as invariably satisfactory. The amount of light required depends entirely on the use to which it is to be put, and illumination that would serve for reading purposes, for example, is not high enough for the observation of close detail at a distance.

Some Views on Street Lighting and Street Photometry.

By An Engineering Correspondent.

We have been hearing a great deal about the objects of street lighting recently. But a short time ago the report of the deputation of the City of London, embodying the results of their tour on the Continent, was issued. Since then the decision of the Westminster Council on the subject of the lighting of the neighbourhood of Piccadilly has excited much comment, and the paper which has just been read by Mr. Abady before the Institution of Gas Engineers is also provoking much discussion.

One is therefore naturally interested in noting the course which discussions on street lighting are taking on the Continent and in the United States. Mr. Abady's suggestions regarding methods of testing the lighting conditions differ radically from those put forward in other quarters—*e.g.*, from the recommendations of the *Verband Deutscher Elektrotechniker* which are likely to be generally adopted in Germany.* It has been suggested by the Photometrical Committee of this body that illumination, whether outdoors or indoors, should be measured in a horizontal plane one metre above the ground, and that both the mean illumination and ratio of the maximum to the minimum value should be stated. In this way one would certainly obtain a general idea of the conditions of illumination, though there still seems room for additional information on another important point, namely the absence or presence of "glare" in the illuminant employed.

It is to be noted that a number of other contributions take the same view—that measurement of illumination in a horizontal plane is, on the whole, the best system of examining street illumination. For instance, Jehl,† describes some tests carried out on the street lighting of Budapest in which this method was followed. It was, however, found desirable to receive the illumination on a special matt white surface consisting of pressed plaster of paris treated with magnesia, so that the actual illumination might approach as nearly as possible the value suggested by the cosine law. In summarizing the results of these tests stress is laid on the ratio of the maximum to the minimum illumination, or, as it is termed, "the co-efficient of distribution." The mean horizontal intensity in the electrically lighted streets, in three cases studied, was 8·45, 8·55, and 5·88 lux respectively while in the gas lighted streets the corresponding figures were 7·6, 12·1, and 8·8. Yet, although the mean horizontal illumination was greater in the latter case the co-efficient of distribution appears to have been exceedingly high, namely 51·6, showing that the illumination was very uneven. A feature of these tests deserving mention was the formation of a specially constituted committee on which, among others, the general managers of the General Electric Co. and the Siemens Schückert works in Budapest, the City engineers and chemists, and a special expert from Berlin assisted.

In some tests on street lighting in Washington* measurement of *illumination* was also utilized. In the streets lighted by magnetite arc-lamps the mean illumination was about 0·062 foot candles; in certain others, lighted by 50 watt Tungsten lamps, the average illumination was 0·013 foot candles.

Yet another contribution on this subject is that of J. Sumec.† This author also discusses in some detail the best method of specifying conditions of street lighting, and he too arrives

* *Illuminating Engineer*, Lond., June, 1910.
† *Elec. World*, April 28, 1910, pp. 1062-1064.

* *Elec. World*, January 6, 1910, pp. 58-60.
† *Elek. und. Masch.*, Jan. 2, 1910, pp. 1-4.

at the conclusion that a measurement of the mean illumination in a horizontal plane was most satisfactory. However, he adds that the product of the mean and the minimum illumination might also be regarded as a useful factor.

In devising street lighting the engineer is invariably confronted by one obvious difficulty. In order to obtain uniform illumination he must secure a powerful intensity at small angles to the horizontal; yet, unfortunately, it is just these rays that tend to shine in the eyes of pedestrians and to produce an impression of glare. It is curious to notice that whereas some authorities on this account prefer a large number of relatively small units equipped with reflectors and placed close together, Sumec and others take just the opposite line. He suggests that our best plan is to use powerful sources a long distance apart and *very high up*. Under these conditions the fact that the light is always relatively far away from the eyes helps to minimize the effect of their brilliancy. He describes one installation which gave very satisfactory results, consisting of flame arcs hung on masts 10 metres high.

A very interesting analysis of the objects of street lighting was recently made by A. J. Sweet.* This author also recognizes that in good street illumination we have to reconcile two requirements, absence of glare and uniform illumination. It is not a very difficult matter to design an ideal polar curve of light distribution for the latter purpose; but it is more difficult to secure that it does not conflict with the former. An important item in making such calculations is the ratio of the distance between adjacent units to the height of the lamps above the street. In America this quantity is often as high as 15. A. J. Sweet, however, both with a view to avoiding glare and also in order to secure uniformity, recommends that this ratio should never exceed 4. When this is done rays can only strike the eye at a comparatively oblique angle. This paper also describes an attempt made by the author to determine the angular range over which rays striking the eyes give rise to an impression of dazzle. In order to investigate this point a series of tests were made on the effect of light sources in the field of view upon acuteness of vision. Naturally a light seen "out of the tail of the eye," though still troublesome, is less distressing than one placed in the direct line of sight. Sweet comes to the conclusion that light entering the eye at angles of more than 30 degrees with horizontal (the horizontal being the

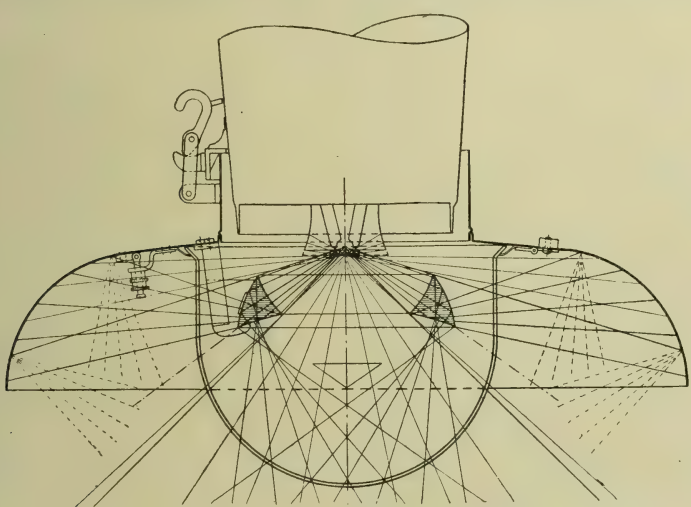


FIG. 1.—"Total Reflector" for use with Flame Arcs.

* *Jour. of Franklin Inst.*, May, 1910, pp. 359-384.

normal direction of vision of people walking down the street) is of relatively little consequence in causing the sensation of glare. In street lighting we ought therefore to shade the eyes from any direct rays which are capable of reaching it within the prescribed angular range. (It may be recalled that L. Weber* also considers that bright sources in interiors should be so placed that the angle between their direct rays entering the eyes and the normal direction of vision should not be less than 30 degrees —a conclusion exactly similar to that reached by A. J. Sweet.)

One illustration of the trend of modern views on street lighting is the gaining recognition than an illuminant intended for this purpose ought to be

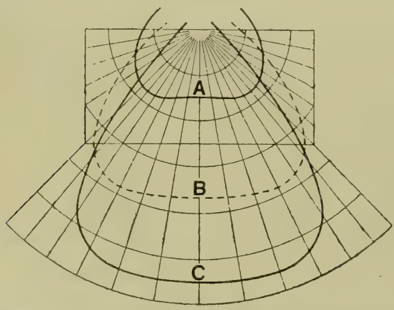


FIG. .—Polar Curves of Flame Arclamp.
(*a*) With ordinary globe.
(*b*) Unscreened.
(*c*) With Total Reflector.

provided with a carefully designed reflector, and that by so doing one can modify the natural distribution of light within wide limits. The well-known dioptric globe, used in connexion with "Excello" arc-lamps, is an example of this tendency.

Another illustration of investigations in this direction is furnished by the "total reflector" for flame arcs designed by K. Hrabowski.† A sketch of this arrangement, and the polar curve to which it gives rise, is given in Figs 1 and 2. The reflector consists of an enamelled metal portion supplemented by a ring of clear glass which totally reflects certain rays falling upon it. The distribution of light is claimed to be influenced in such a way that the light is strengthened in directions only slightly inclined to the horizontal, and yet it is also intended to suppress glare. Thus rays between 45° and the vertical, which are not likely to enter the eyes direct, are allowed to pass unimpeded, but rays outside this angle are to some extent diffused by the reflectors and their glaring effect is lessened. It is also contended that fumes from flame carbons do not deposit on the glass ring owing to its high temperature and that the loss of light in reflection is only 11 per cent; this the author considers to be about the minimum theoretically possible.

Yet another example of recent designs in reflectors is the "Equilux" of C. H. Sharp.* The appearance of this reflector will be understood from Figs 3 and 4. It is expressly

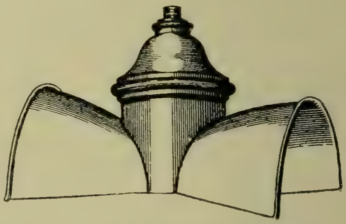


FIG. 3.—The "Equilux" Reflector.

designed to direct the light to quarters where it is most needed and to produce a uniform illumination. Unlike most globes and reflectors designed for the purpose, it is not symmetrical about the vertical axis, but is intended to throw back into the street light which would otherwise escape sideways. There seems no doubt that this latter point is rather an important one, though some objection might possibly be taken to the appearance of this reflector from an artistic standpoint. At present there is often a great deal more light thrown out sideways on to the walls and houses than is really necessary. One need not assume that light should be entirely restricted to the lower hemisphere, but it must be admitted that in London, owing to the griminess of most buildings, a very large portion

* *Illum. Eng.* Lond., Vol. III., Feb., 1910, p. 116.
† *Elektrotechn.* Zeitschr. Jan. 6, 1910, pp. 11-13.

* Paper read before the American Illuminating Engineering Society, New York, May 12th, 1910.

of the light reaching them is absorbed and wasted. Possibly the use of good reflecting surfaces may in future form a more important item in connexion with street lighting. A. Bohle* has described how in Cape Town the provision of good lighting in the streets is very much simplified by the whiteness of the buildings and the large amount of light reflected from them. Another example of the waste of light emitted sideways from street lamps is provided by the lighting up of certain hoardings and advertisements. One could mention certain advertisements in the Strand, the value of which must be very much enhanced by the fact that flame arcs and incandescent mantles in their neighbourhood throw a very large portion of their light straight on to the posters throughout the evening. It is something of an anomaly that light intended for the public benefit should be suffered to serve this end.

FIG. 4.—The "Equilux" Reflector in position.

Returning to the question of glare, one cannot but feel that it might often pay to sacrifice a certain amount of brilliancy by the use of diffusing globes. It is quite possible that by so doing we might, in spite of the loss of light, be able to see our way about easier, and one would like to see further experiments made on this point. In the writer's experience it is often impossible to distinguish the features of a person coming towards one, and only a few yards away—and this in spite of the fact that the illumination may be unusually high. The explanation seems to lie in the fact that the eye is distressed by seeing the bright sources in the background, and an unmistakable gain in distinctness can usually be secured by screening the eyes with the hand.

It is often suggested that people like to see a row of bright lights down each side of the street, and that this gives rise to an impression of cheerfulness. But if this be true it is also true that the cheerfulness would be in no way diminished, and the comfort to eyesight of pedestrians would be improved, by reducing the intrinsic brilliancy of such sources. An interesting move in this direction has recently been made in Newark in the United States and elsewhere, where clusters of Holophane globes, surrounding tungsten glow-lamps have been used for street lighting. This method is exhibited in Fig. 5.

FIG. 5.

Lastly, it may be of interest to mention one new electric source of light which may prove an interesting addition to street illuminants namely the quartz tube mercury vapour lamp. This lamp has been previously de-

* *Illum. Eng.* Lond., Vol. I., 1908, p. 611.

scribed in *The Illuminating Engineer*.* The mechanical construction is not unlike that of the ordinary mercury vapour lamp, the main distinction being the use of a special small quartz glass tube which permits of a much higher temperature. The specific consumption is said to be as low as 0·25 watts per candle. At the high temperature of the tube the line spectrum of mercury broadens out into a more or less continuous one giving a whitish yellow light tinged with green; this contains a distinct red constituent. In order to absorb the ultra-violet rays a special dense lead glass diffusing globe is placed round the source.

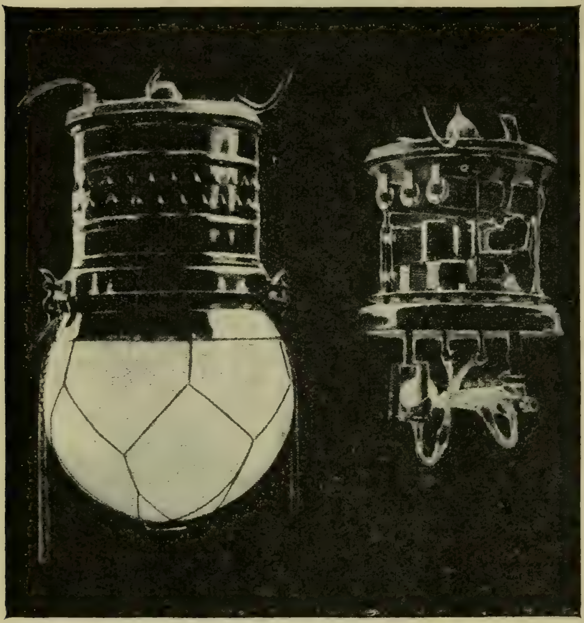


Fig. 6.—The Quartz Tube Mercury Vapour Lamp.

A number of these lamps have recently been introduced in Paris giving 1,000 and 2,000 candle-power. They are said to require practically no attention during their usual life of 2,000 hours, and the luminous mercury tube, placed as it is inside the dense diffusing outer globe, is said to give rise to an exceedingly soft illumination, the intrinsic brilliancy being quite exceptionally low. Fig. 6, which illustrates the general appearance of the lamp, is taken from a recent number of *Popular Electricity*.

* *Illuminating Engineer* Lond., Vol. I., 1908, p. 81; Vol. II., 1909, p. 170.

Testing the Strength of Metallic Filaments.

A recent paper by T. Muller*, describes a method of testing the shock-resisting power of metallic filaments. A small rubber ball is allowed to fall down an inclined plane and impinge upon the lamp-bulb at the base of it. The speed of the ball, and therefore the intensity of the shock, depends upon the distance the ball is allowed to roll before impact. In testing a lamp the distance of roll is gradually increased until the filament gives way, and in this manner the durability of different types of lamp can be tested. As was expected the lamps of low voltage and high candle-power possessed the greatest strength, but it was rather difficult to draw conclusions regarding the relative fragility of lamps of the same class. Lamps when alight were much more difficult to break than when the filament was cold. The filament itself was not invariably the most fragile part of the lamp, breakages sometimes occurring in the supporting glass rods and hooks.

* *Electrician*, April 28, 1910.

The Johns Hopkins Course of Illuminating Engineering.

To be held at the Johns Hopkins University, Baltimore, U.S.A.

(From *The Electrical World*, N.Y., June 2nd, 1910.)

THE Illuminating Engineering Society has arranged for a course of thirty-six lectures on illuminating engineering, with accompanying laboratory work, at Johns Hopkins University, Baltimore, extending from October 26th to November 8th, 1910. The lectures, which will be given under the joint auspices and control of the Society and the University, will follow immediately the annual convention of the society which, upon the invitation of the President of the Johns Hopkins University, will be held at that institution, beginning Monday, October 24th, 1910.

The origin of the course was due to a recognition by the Society that there is an increasing demand for trained illuminating engineers and that the present facilities available for the specialized instruction required are inadequate. The specific objects of the course are to indicate the proper co-ordination of those arts and sciences which constitute illuminating engineering; to give practising engineers an opportunity to obtain a conception of the science of illuminating engineering as a whole, and to furnish a condensed outline of study suitable for elaboration into an undergraduate course for introduction into the curricula of undergraduate technical schools. The subjects and scope of the lectures have been proposed by the Society and approved by the University. The lecturers have been invited by the University upon the advice of the Society.

The University will provide facilities for demonstrations at lectures and will also have installed a working exhibit of apparatus for experimental work in light, illumination, and illuminating engineering. This apparatus will be at the disposal of those who attend and an opportunity will be afforded to undertake laboratory work during the term of the lecture course under the supervision of trained experts of the University and of the Society. A fee of $25 will be charged for admission to the course and to the accompanying laboratory instruction. Following is a list of the lectures:

'The Physical Basis of the Production of Light' (three lectures); Joseph S. Ames, Ph.D., Professor of Physics, the Johns Hopkins University. 'The Physical Characteristics of Luminous Sources' (two lectures); Edward P. Hyde, Ph.D., President Illuminating Engineering Society; Director of Physical Laboratory, National Electric Lamp Association. 'The Chemistry of Luminous Sources' (one lecture); Willis R. Whitney, Ph.D., Director of Research Laboratory, General Electric Company; Past President, American Chemical Society. 'Electric Illuminants' (two lectures); Charles P. Steinmetz, Ph.D., Consulting Engineer, General Electric Company; Past President, American Institute of Electrical Engineers; Professor of Electrical Engineering, Union University. 'Gas and Illuminants' (two lectures); (1) M. C. Whitaker, B.S., M.S., Professor of Industrial Chemistry, Columbia University (2) Alexander C. Humphreys, M.E. Hon. Sc.D., President of Stevens Institute of Technology; Past President, American Gas Institute. 'The Generation and Distribution of Electricity, with Special Reference to Lighting' (two lectures); John B. Whitehead, Ph.D., Professor of Applied Electricity, the Johns Hopkins University. 'The Manufacture and Distribution of Gas, with Special Reference to Lighting' (two lectures); (1) A. G. Glasgow, M.E, M.I.C.E., London, England; (2) Mr. Walter R. Addicks, Vice-President of Consolidated Gas Company, New York. 'Photometric Units and Standards' (one lecture); Edward B. Rosa, Ph.D., Physicist, National Bureau of Standards. 'The Measurement of Light' (two lectures); Clayton H. Sharp, Ph.D., Test Officer, Electrical Testing Laboratory, New York City; Past President, Illuminating Engineering Society. 'The Architectural Aspects of Illuminating Engineering' (two lectures); Walter Cook, A.M., Vice-President, Ame-

rican Institute of Architects; Past President, Society of Beaux Arts Architects. 'The Decorative Aspects of Illuminating Engineering' (one lecture); Mr. Louis C. Tiffany, President of the Tiffany Studios, New York. 'The Physiological Aspects of Illuminating Engineering (two lectures); P. W. Cobb, B.S., M.D., Physiologist of the Physical Laboratory of the National Electric Lamp Association. 'The Psychological Aspects of Illuminating Engineering' (one lecture); John B. Watson, Ph.D., Professor of Experimental Psychology, Johns Hopkins University. 'The Principles and Design of Interior Illumination' (six lectures); (1) L. B. Marks, B.S., M.M.E., Consulting Engineer, New York City; Past President Illuminating Engineering Society; (2) Mr. Norman Macbeth, Illuminating Engineer, the Welsbach Company. 'The Principles and Design of Exterior Illumination' (three lectures); (1) Louis Bell, Ph.D., Consulting Engineer, Boston, Mass., Past President, Illuminating Engineering Society; (2) E. N. Wrightington, A.B., Boston Consolidated Gas Company. 'Shades, Reflectors, and Diffusing Media' (one lecture) Van Rensselaer Lansingh, B.S., General Manager of Holophane Company. 'Lighting Fixtures' (one lecture); Mr. Edward F. Caldwell, senior member of firm and designer, Edward F. Caldwell & Company, New York. 'The Commercial Aspects of Electric Lighting' (one lecture); John W. Lieb, Jun., M.E., third Vice-President of New York Edison Company; Past President, American Institute of Electrical Engineers. 'The Commercial Aspects of Gas Lighting' (one lecture); Walter Clark, M.E., President of the Franklin Institute, Philadelphia; Third Vice-President, United Gas Improvement Company, Philadelphia. The laboratory demonstrations will be under the direction of Mr. Charles O. Bond, manager of photometric laboratory, United Gas Improvement Company, Philadelphia; Dr. Herbert E. Ives, Ph.D., physicist, Physical Laboratory, National Electric Lamp Association, and Mr. Preston S. Millar, Electrical Testing Laboratories, New York; General Secretary, Illuminating Engineering Society.

Portable Acetylene Lights for Emergency Lighting.

Acetylene lights are said to be finding a useful field in connection with the illumination of buildings during erection, for railway work, for unloading heavy goods from ships, and in other cases where a powerful portable source of light is needed during night work, and gas and electricity are not available. The illustration on the opposite page, for example, taken from a photograph kindly lent us by the Imperial Light Co. Ltd., shows such an acetylene outfit in operation. It is stated by the makers that an outfit capable of giving 350 candle power can be moved from place to place, when fully charged, by a single man. Such an apparatus consumes about 12 oz. of carbide per hour, and will run for twelve hours without requiring a recharge. Similar outfits yielding 1,000 and 3,500 candle-power are also available.

Attention was called to the value of acetylene for emergency lighting by the recent floods in Paris; during this time the gas and electricity supplies were both out of action. The apparatus shown in the illustration contains a generator, but, as has been pointed out previously in these columns, dissolved acetylene in tubes has also been found effective for emergency lighting in churches during festivals, &c.* A special advantage claimed for such dissolved acetylene outfits is said to be that they can be attached to the supply mains usually fed by a generator in the event of its being temporarily out of action. For the same reason twin generators, one of which can be put into action at any moment while the other is being cleaned or charged, are sometimes employed.

* *Illuminating Engineer*, Jan., 1910, p. 53.

FIG. 1.—Imperial Acetylene Outfit in use during construction of Council House, Birmingham. Photograph taken about 10 o'clock on a November night, no other artificial lighting used.

Lighting Hospital Wards.

IF direct lighting is to be used and the usual arrangement of beds prevails—*i.e.*, a double row with an aisle through the centre of the room—a row of central chandeliers is the only feasible method. The one necessary precaution is then to fit each lamp with a diffusing globe that will entirely hide the form of the lamp filament.... To have bare gas or electric lamps in such a position that they can shine in the patient's eyes is a condition which cannot possibly be condoned on any grounds. — *The Illuminating Engineer* (New York), June, 1910.

On the Radiation from Metals.

By Edward P. Hyde.

(Abstract of a paper presented before the American Physical Society, Washington, April 22, 1910.)

In a previous paper[1] before the New York Section of the Iluminating Engineering Society the author, in collaboration with Messrs. Cady and Middlekauff, presented the results of the application of two new photometric methods to the study of the selective[2] radiation of certain metals. These two methods are described in some detail in the papers to which reference is made, so that it is unnecessary to discuss them here. It might be well, however, to repeat briefly the assumptions which are involved in the two methods.

If it is admitted that of the power supplied to an incandescent filament mounted in an exhausted bulb, as in ordinary commercial lamps, that lost by conduction and convection is small compared with that radiated,[3] the two photometric methods give positive qualitative criteria of the relative selectivity of the radiation from the various filaments investigated. Thus, suppose two filaments operated at such voltages that the ratio of the energy radiated in some wave-length in the red end of the visible spectrum to that radiated in some wave-length in the blue end of the spectrum is the same for both. If under this condition the two filaments show quite different lumens per watt, it must follow that the partition of energy in the complete spectra of the two is different, and hence one radiates selectively with respect to the other. This is a necessary conclusion irrespective of any other knowledge whatever regarding the properties of either substance, either in the visible or in the infra-red region of the spectrum.

Should the two filaments under the given condition have the same lumens per watt, it is *probable* (particularly for carbon and the metals studied), though not *necessary* that the two infra-red energy curves should agree throughout. In other words, If the lumens per watt are found to be the same there may or may not be relative selectivity, though for the substances studied the latter alternative is more probable ; if the lumens per watt are found to be different there is without question relative selectivity.

The quantitative measurement of the selectivity rests on the assumption that if two metals, when at the same relative distribution of energy for two wave-lengths in the visible spectrum, show different lumens per watt, the filament having the lower lumens per watt is at the higher temperature. This is probable from what is known regarding the reflective power and other properties of metals. On the basis of the assumption the numerical differences between the lumens per watt of the various filaments indicate in every case the minimum value of the difference in efficiency due to selectivity.

In the former discussions of these methods the condition of comparison of the various filaments has been stated as being a "colour match," or the same distribution of energy in the visible spectrum as determined with a spectrophotometer. As a matter of fact, when the *relative* emissivities at two wave-lengths not too near the extremes of the visible spectrum are the same for

[1] *Trans. I.E.S.*, Vol. 4, p. 334 1909. See also *Elec. World*, Vol. 53, p. 439 1909 ; *Phys. Rev.*, Vol. 27, p. 521, 1908: *Illum. Eng.* (London), Vol. 2, pp. 241-335, 1909.

[2] Throughout this paper the term "selective radiation" is used to signify merely a different distribution of energy from that radiated by a "black body" at the same temperature. The term is not used in this paper to imply pronounced bright lines or bands in the spectrum, as is frequently understood.

[3] This conclusion has been corroborated by Drysdale (see London *Illum. Eng.*, Vol. 1., pp. 27 *et seq.*, 1908), and Fery & Cheneveau (see *Bull. de la Société Internat. des Electriciens*, Series 2, Vol. 9, p. 655, 1909), while Lux (See London *Illum. Eng.* Vol. 1, p. 98, 1908), has found quite appreciable differences between the energy input and that radiated.

any two of the various filaments studied, observations with the spectrophotometer show that over the entire range of the spectrum within the two given wave-lengths, the distribution of energy is the same for the two filaments to within less than 2 per cent., perhaps less than 1 per cent. Moreover, the integral colours, as seen in an ordinary Lummer-Brodhun contrast photometer are closely the same. Osmium alone seems to differ enough to be noticeable, and the corresponding spectro - photometric measurements show the slightest evidence of a relative depression in the middle of the visible spectrum, making the integral colour slightly purplish compared with carbon.

As the measurements of relative energy in the spectra of carbon and tungsten, for example, are carried out into the deep red, and infra-red, as with a bolometer, the relative distribution must gradually become different since the lumens per watt under the given conditions are much greater for tungsten than for carbon. It is difficult to understand, however, how two filaments could show markedly different relative distributions of energy well within the visible spectrum, and still be at a colour match, as was recently found by Coblentz[4].

In the previous paper, on the basis of the assumption stated above, numerical data were given of the relative selectivity of carbon (as it occurs in the various types of commercial carbon lamps), tantalum, tungsten, and osmium. Since then it has been possible through the use of very special lamps made of platinum wire to determine the position of platinum in the series mentioned above. The results obtained with platinum, together with the values found for the Lummer-Kurlbaum electrically heated "black body," which had been studied previously, are of considerable interest because the "black body" and platinum have constituted the two reference points for much of the published data on the radiating properties of various substances.

It was not feasible at the time to determine the lumens per watt of the "black body," so that the results on the "black body" were obtained solely by the other method, viz., that of measuring the ratio of the change in candle-power to that in watts when the "black body" was operated at such a temperature that its radiation matched in colour that from the standard lamp at the chosen voltage. The results found for the "black body" place it at the head of the list, all the filaments showing selectivity in different degrees, but in the same direction, viz., in favour of the shorter wave-lengths. Untreated carbon comes nearest to the "black body," but there is indication of a very small selectivity even for that.

The measurements on the "black body" which were carried out two years ago were made possible through the courtesy of Drs. Waidner, Burgess and Coblentz, of the Bureau of Standards, who kindly placed two different electrically heated "black bodies" at the disposal of the author.

Platinum was studied by both of the photometric methods, and at two different temperatures. The results in every case indicated that its position in the series lies between the carbons on the one side, and tantalum on the other. In other words, it is more selective than carbon in any of its forms, but not as selective as tantalum, tungsten or osmium, which lie in the order named, osmium being much more selective than tantalum.

The results obtained for platinum are of especial interest because platinum has commonly been considered as deviating farthest from "black body" radiation. As has been pointed out several times, this deviation may arise either from a low emissivity throughout the spectrum or from a pronounced selectivity, or from a combination of these. It is quite possible that platinum may deviate farthest, when both emissivity and selectivity are considered, but from the standpoint of selectivity alone, which determines the photometric efficiency, all three of the metals, tantalum, tungsten, and osmium are more selective, judged by the photo-

[4] Bureau of Standards Bulletin, vol. 6, No. 3, p. 301, 1910.

metric criteria, and making the assumption stated in an earlier paragraph. On the basis of the same assumption, Henning[5] recently deduced lower limiting values of the emissivity for various metals. He found as the lower limit for platinum 0·17, for tantalum 0·27, for tungsten 0·40, and for osmium 0·62. Thus, platinum probably has a lower emissivity than tantalum tungsten, or osmium, all of which in turn are more selective than platinum. These lower limiting values for the emissivity of the various metals, tantalum, tungsten and osmium, can be obtained roughly from the red "black body" temperatures at colour match, as pointed out in the previous paper[6] by Cady, Middlekauff and the author.

The apparently independent variation in the two variables, emissivity and selectivity, emphasizes the significance in the study of selectivity of making the basis of comparison the same *relative* emissivity at two wave-lengths for the various filaments rather than the same *actual* emissivity at some one wave-length. Thus when tungsten and treated carbon, for example, are at such temperatures as to have the same *relative* emissivity at say $\lambda = 0{\cdot}66\ \mu$ and $\lambda = 0{\cdot}5\ \mu$ (which amounts to a colour match), the tungsten shows a value of lumens per watt from 20 to 40 per cent. higher than that of treated carbon, the amount of the difference depending upon the absolute temperature at which the comparison is made. If on the other hand tungsten and carbon are at such temperatures as to have the same *absolute* emissivity at $\lambda = 0{\cdot}66\ \mu$ experiment shows that the difference in lumens per watt between the tungsten and the carbon is approximately twice that at colour match. Therefore, of the difference in lumens per watt between tungsten and carbon when operated at such temperatures that the energy emitted at λ $0{\cdot}66\ \mu$ is the same for the two, approximately one-half is due merely to the different *emissivities* of the two substances, the remaining half being due to *selectivity*.

[5] Zs. für Instrk., vol. 30. p. 74, 1910.
[6] Loc. cit., *Trans. I.E.S.*, p. 351.

(*To be continued.*)

The Intrinsic Brilliancy of Walls and Ceilings.

We are accustomed to figures comparing the intrinsic brilliancy of various illuminants. Dr. Stockhausen, for example, (*Illuminating Engineer*, London, February, 1910, p. 113), has stated that the intrinsic brilliancy of the candle is about 3 c.-p. per square inch, that of the incandescent mantle 25–30 c.-p. per square inch, and that of the metallic filament lamp near 1,000 c.-p. per square inch. Various authorities, as a result of a study of the brightness of the sky and other considerations, have named 2·5 c.-p. per square inch as about the maximum absolute permissible intrinsic brilliancy of sources used in interiors.

There have hitherto not been many figures available for the intrinsic brilliancy of the illuminated surfaces usually met with in interiors, but Dr. C. H. Sharp and Mr. P. S. Millar, in a paper before the Illuminating Engineering Society in the United States on May 12th of this year gave some results on this point. As a mean value for the brightness of the ceilings and walls in the interior studied they give 0·003 c.-p. per square inch. As these are the kind of illuminated surfaces which serve as a background to the eye under normal conditions the figure should be useful as a guide to the safe intrinsic brilliancy of sources. Thus, assuming Prof. L. Weber's recommendation that the contrast between the brightness of a source and its surourndings should not exceed 100 to 1, we find that the intrinsic brilliancy of the source itself should not exceed $0{\cdot}003 \times 100$, *i.e.*, 0·3 c.-p. per square inch—a somewhat lower figure than that mentioned above.

Short Notes on Illuminating Engineering.

From all Sources.

The Local Government Board and Illumination.

As has several times been suggested in these columns, it is desirable, if the Local Government Board really means to supervise local lighting conditions, that its opinions should be backed by technical expert assistance which inspires respect, and that its impartiality and unbiassed attitude should be generally recognized. A central authority having these qualifications could often render considerable service by acting as arbitrators in cases of dispute, collecting information, and, when desired, giving advice on public lighting.

Meantime it is to be noted that dissatisfaction with the present arrangements is expressed in various quarters. In *Electrical Industries and Investments* (May 18th, 1910) reference is made to Mr. Ross Hooper's inquiry at Grimsby when he is reported to have remarked :— " .. The gas lighting seems to be very fair in Grimsby. I have been through many streets at night." In this connexion the journal adds " So far as we know, Local Government Board Inspectors are not fitted with photometric eyes and the impressions gathered by them in nocturnal rambles are hardly evidence."

Good Gas and Good Service.

If good gas be the corner stone of a gas company's success, then good service must be the keystone, and therefore no efforts should be spared to please every consumer as far as possible. Liberality pays in commercial business, why not in gas ?—*Light*, May, 1910.

The Opportunities for the Contractor and the Illuminating Engineer.

The illuminating engineer, then, has his justification as far as we are concerned ; indeed, judging from the illuminating effects obtained in many public and other buildings to-day, he or somebody filling a similar role is essential.... We hear a lot about the " Satisfied Consumer " to-day. Then let us see that he is satisfied. Let the contractor look to it, *the illuminating engineer scheme for it*, the central station engineer and the lamp-maker work for it too.—*Elec. Review*, April 1st, 1910.

The Eyesight of School Children.

That the vision of " leavers " has been found to be worse than that of " entrants " indicates that school life has a detrimental effect on eyesight, but the question of prevention involves many considerations. The chief causes of short sight, so far as school life is concerned, have been clearly described by Dr. J. Wheatley in his first report to the Shropshire Education Committee as follows :—

1. Insufficient or improper lighting of the schoolroom.
2. The construction of the desks.
3. The books used—type and paper.
4. The attitude of the children when occupied in near work.
5. The length of time the children are kept at near work ; both the gross time per day and the time without a break.
6. The age at which near work is begun.—*The Medical Officer*, May 28th.

Testing the Steadiness of Sources of Light.

ALTHOUGH frequent reference is made to the "steadiness" of this or the other source of light, comparisons must always remain a matter of conjecture unless we have some means of actual testing the variation in candle-power.

In this connexion some experiments of E. Presser (*E. T. Z.*, February 24th, 1910) are of interest. This investigator has pointed out that although the selenium cell is too uncertain in action to be used for absolute light measurements, it can, nevertheless, be effectually applied for *comparative* measurements of the light from one and the same source. Some "physical" test of this kind would seem to be needed, for the light from some lamps fluctuates so rapidly that it would be difficult to obtain a photometric measurement before the conditions had changed.

In Presser's method the changes in resistance of a selenium cell, due to fluctuations in the light impinging upon it, are recorded on a moving drum, and the behaviour of different kinds of arc-lamps and gas-lamps can be readily compared in this way. It appears that selenium cells have in the past also been applied to study variations in daylight, solar eclipses, &c.

Reputation and Fixture Design.

THERE is not in the entire fixture trade to-day a single designer of popular repute....

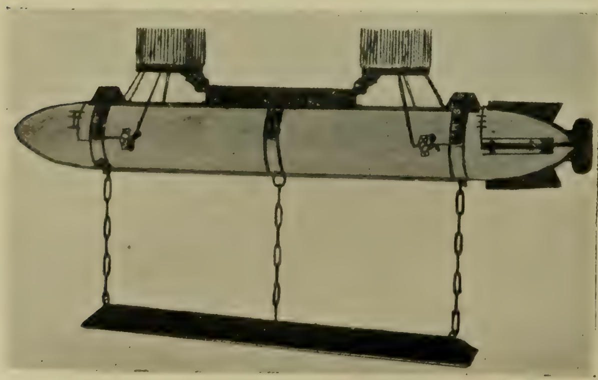
This unfortunate condition in fixture manufacture is not wholly, nor perhaps largely, due to the fact that there are no designers of real power and originality. A greater cause is the failure of the manufacturer to recognize the importance of personality. No matter how expensive or elaborate the fixture, or how important the building for which it is made, it goes out like a waif and a foundling, without bearing the slightest mark or trace of its parentage. It is not stamped with the personality of an individual, but is simply the unnamed product of a factory. Is it any wonder that the fear of imitation terrorizes the entire guild of fixture makers?....

A book publisher advertises the name of the illustrator and author; oftentimes a considerable part of the value depending upon the reputation of the former. Why should not the value of a fixture depend at least as much upon the name of its designer?—*The Illuminating Engineer* (New York), June, 1910.

A Zeppelin Airship Fixture.

BY AN ENGINEERING CORRESPONDENT.

SOME time ago a third son was born to the German Crown Prince. Count Zeppelin, being one of the godfathers on this occasion, conceived the happy idea of presenting a miniature airship, in the form of a lighting fixture, to the baby prince. The nature of the model is shown in the accompanying illustration. There are two incandescent lamps inside the body and two others within the cars, which are made of crystal glass. The over-all length is one metre and is suspended on chains which also serve to conduct the current.



The Lighting of the Old South Kensington Museum.

(By an Engineering Correspondent.)

Having considered the electric lighting of a number of typical galleries in the new portion of the Victoria and Albert Museum in the May issue of this journal, we will now proceed to examine some of those in the older section, many of the galleries of which are dove-tailed into the newly built courts so that a stranger is not always conscious of the spot at which he crosses the dividing line.

The conditions to be met and the nature of the objects to be lighted are very similar in the two cases, but the difficulties encountered in the designing of the installation are widely different. In the former case it has been possible to lay out a large scheme as a whole, to take advantage of every modern improvement in lamps and other apparatus and to act on the experience of more than a generation of electrical engineers. How far the result has been successful, hampered as it has been by the human administrative machinery which produced it, and how much the illuminating engineer has still to teach the engineering world, we have already seen.

In the older buildings the problem was very different. The difficulties were the difficulties of pioneers, the work had to be undertaken piecemeal, each section an experiment, each experiment cramped by crude and expensive materials.

The early stages were entered on more than 30 years ago under the control of the Royal Engineers. Later on the museum officials under the Board of Education took charge and last year the responsibility passed on to the Engineering Division of H.M. Office of Works. In that time much has been done, much has been, and is being, altered and re-altered, and very much remains to be done still. The collections have been arranged and re-arranged: metal-work has replaced sculpture, lace-work has followed metal, pictures have supplanted porcelain—especially in the transporting of so much of the collection to the new galleries But the lighting has lagged far behind: always improving certainly but very slowly. Many of the troubles encountered in the early days were in electrical details such as do not greatly concern us now, although doubtless they retarded progress considerably at the time. The result of lack of continuity in both plans and personalities and the spasmodic manner in which the work has been carried out, has resulted, as might be expected, in a patchwork of very varied styles.

After these prefatory remarks let us enter the building from the Exhibition Road door, and, passing down the steps and through an arc lighted gallery of the new building, turn to the right into the West Court (41). Until about two years ago this was the room used as the Science Library which was afterwards transferred to the New Royal College of Science across the road. A large amount of builder's work and re-decoration had to be done at the time of this alteration, and it is surprising that such an opportunity of re-organizing the lighting arrangements was not taken advantage of. The need for this is strikingly evident owing to the court being bounded on one side by the well-lighted new Octagon Court and on the other by the glaring West Central one.

The size of the court is 93 ft. by 50 ft., and the lamps are eight very ancient 10-ampère open-type arcs, four in series on 200 volts. This gives the low consumption of 0·86 watt per square foot of floor-space and, to make matters worse, the lamps have large bottom-carbon holders which obstruct much of the light. When it is added that the lamps are 28 ft. from the floor the general gloomy appearance of the court

will be readily understood. The objects themselves are not calculated to relieve this as the walls are covered with heavy Persian rugs and carpets and the centre cases are filled with dark, Japanese lacquered articles. About 22 ft. from the floor there is a balcony round this court, with Alfred Steven's sketches and some Japanese paintings on the walls, and this is the only well-lighted portion of the gallery, and it may even be that it is on account of it that the lamps are not lowered.

Coming back down the steps from this court we are faced by four small galleries containing Persian and Saracenic arms and armour (Nos. 17 to 20) which have recently been relighted by means of bronze fittings similar in type to those employed in the new portion. There are these differences, however, that, whereas the latter have 6–28-watt, obscured, metallic-filament lamps at 9 ft. from the ground, the former have five clear ones of 40 watts and hang 14 ft. up. The current consumption is rather less than 0·7 watt per square foot and a good light, well diffused, is obtained which displays even such dark objects as these very satisfactorily.

Instead of passing through these rooms we will turn to the right along the gallery which was formerly devoted to plaster casts of statues and which for years was the usual entrance to the museum. At that time the lighting was of a heterogeneous character including small arc lamps, carbon incandescents, tantalums and Nernst. In rearranging this space for iron-work the lighting has also been put in order, with very good results. The length of this section (Galleries 22, 23, and 24) is 230 ft., and the width about 34 ft. The new arrangement of lighting is by 28 pendants in a double row, each pendant a 6-light ball of tantalums at a height of 14 ft. The exhibits are principally iron gates, scroll work, &c., which do not demand any niceties of light and shade, but an abundant quantity of illumination, and this is what has been provided, and in a far pleasanter way than in the arc-lighted continuation of the gallery which forms the portion of the new building connecting this with the entrance.

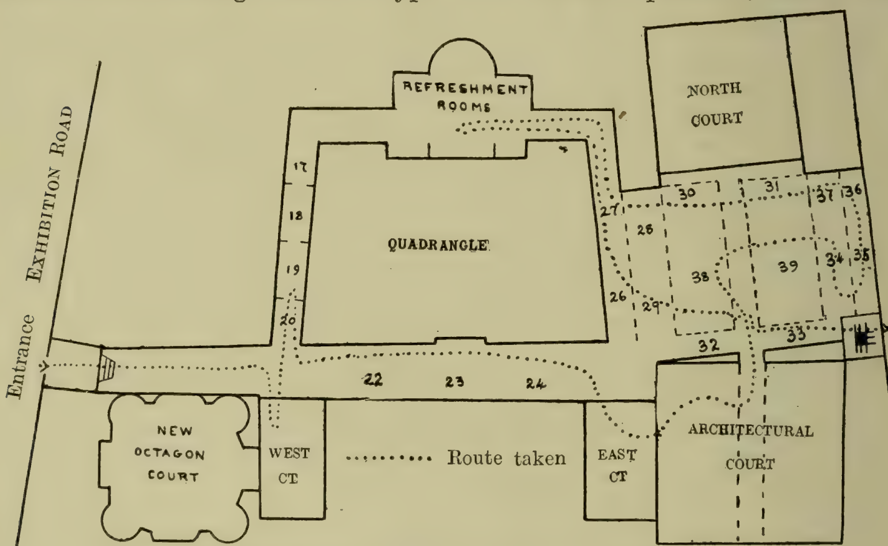


FIG. 1.—The Old South Kensington Museum (Ground Floor).

In the East Court (No. 45) the lighting of the tapestries and musical instruments is but poor although it is not so bad as that encountered in the West Court as the arc lamps are of a more modern type and take a slightly larger current. Still, even so, there is less than 1 watt per square foot, and the lamps are again hung above the height of the balcony round which are Japanese

embroideries and reproductions of the Bayeux tapestry.

But pass on and walk warily. We are entering the old architectural court, a city of dreadful night, dominated by the towering column of Trajan, crowded with monuments and ancient masonry through the mazes of which the visitor is guided by the glimmer of an occasional arc-lamp far up in the vastness of the roof. And this is open for the students of earth's richest city!—has been so for years. Yet even in the dimness you may find, here and there, some undaunted learner sketching a cornice or copying a moulding, so imperative are modern requirements in the building world.

In all seriousness it is high time that this state of affairs should be attended to. Here we have a large court, only one-half of which is at present open to the public, but that half in itself is more than 120 ft. long and 60 ft. broad, filled with immense shadow-casting objects and the walls painted a dark reddish-brown, lighted only by twelve 10-amp. open-type arc-lamps which are, moreover, hanging 33 ft. from the floor with nearly 30 ft. of space above them before a non-reflective roof is reached. 0·83 of a watt per square foot would be little enough for arc lighting under most circumstances; in conjunction with the disadvantages just enumerated it is absurd.*

In the South Court, a large court with an arched roof of iron and glass, a large variety of metal objects from gold and silversmiths' work and jewelry to bronze knockers and homely pewter ware, is arranged. The main body of the hall is in two sections divided by a wide passage and a bridge on the first floor over that. Each of these sections (38 and 39) is 105 ft. long and 50 ft. wide, and is lighted by eight 10-amp. open-type arc-lamps at 24 ft. from the ground. A certain amount of additional light is received from the incandescent lamps on the first floor bridge just mentioned and which will be dealt with later, but, as these lamps are 30 ft. up, the amount is inconsiderable. The objects are generally of small size and are placed in 6 ft. cases, which, in the centre of the hall, are well lighted, with the possible exception of a few of the darker metal statuettes. The cases at either end, however, are entirely unlighted on the sides nearest the walls and additional lamps are required to remedy this. There are, moreover, small galleries crossing the ends of this court (Nos. 30 to 33) which are destitute of light except for what is received from the arc-lamps in the central portion, which, of course, is only sufficient for getting about purposes, and not for examining objects. In fact, if the areas of these cross galleries are added, the floor space served by the arcs amounts to 6,500 square feet, bringing down the watts per foot from 0·8 to 0·6. However, it would be fairer to regard only the central portion of the main courts as being lighted and in that case something like 1 watt per square foot would be correct.

This court is bounded on either side by two parallel 20-ft. galleries, separated from the larger court and from each other by columns, the two outer ones having side windows and the intervening ones being lighted by day partly from these windows but principally from the roof of the South Court. The method which has been adopted for treating the eastern of these galleries electrically is by means of battens of 3–40-watt metallic, or 5–16 c.-p. carbon filament lamps over each window, making a row of lights about 2 or 3 ft. apart the full length of the gallery. The lamps are aided by white enamelled "trough" reflectors, set at a suitable angle to throw the light to the further side of the gallery. The inner gallery is lighted in a similar manner by battens fixed under the cornice on the side nearest the South Court, *i.e.*, the side from which the greater part of the light is received by day. In galleries 34 and 35 the result is to be highly commended, and provides a good example of how such lighting ought to be done, as the daylight illumination is maintained both in direction and quantity. The

* In the other half of this court, visible from the first-floor bridge, is a replica of the Hildesheim chandelier, illustrated in the *Illum. Eng.*, April, 19.0.

adjoining smaller gallery No. 36 has been treated on similar lines, but is not provided with a sufficient number of lamps.

On the western side the battens, instead of being fixed at cornice height, are placed across the windows, only 12 ft. from the floor instead of 19 ft. The objects to be shown are medallions and seals in desk-top cases, and the ends nearest the windows are very well lighted at the expense of the farther ends. With the battens raised to a corresponding height to those on the east, and possibly increased somewhat

.... Route followed.

FIG. 2.—Old South Kensington Museum (First Floor).

in candle-power, a more even effect might be obtained. These galleries, however, unlike those on the east, receive no assistance from the inner ones (Nos. 28, and 29), which are not lighted at all.

It is difficult to give the figures in watts consumed per square foot, owing to the numbers of lamps in the battens ranging from three to six inclusive, and to the varieties of types employed comprising ordinary 16 c.-p. carbon filament lamps, mushroom-shaped, silver-backed "improved" glow-lamps, 40-watt Osrams, and 21 c.-p. tantalums, the latter sometimes set at an upward and sometimes at a downward angle. The general impression conveyed is that the whole arrangement is experimental, or is it that some economist is finishing up old stock? If so, why do it in a public part of the museum? There are surely opportunities enough in the sections reserved for the Circulation Departments or other purposes, and further, if economy is the object, one might suggest the application of a hammer in some cases if redness is any sign of a lamp's age and efficiency.

The corridor outside the refreshment and dining-rooms was formerly lighted by a dozen 300 c.-p. Welsbach self-intensifying gas lamps at a height of 18 ft., their tops being inserted into a ventilating shaft to carry off the fumes. Although these still remain in position, their use has been discontinued in favour of a double row of eleven 4-light pendants of tantalums, 14 ft. from the ground. The gallery is 225 ft. long by 24 ft. wide, for which the provision is inadequate (being in fact less than 0·3 watt per square foot), especially as the exhibits are dark Chinese and Japanese bronzes and armour. There are in addition 1,000 sq. ft. of recesses in the centre section for which nothing has been attempted at all.

The large North Court, which formerly held various wooden statues and architectural exhibits, is now closed to the public so that a favourite place of assignation, "under the clock," is no longer available: there are, however, numerous other seats-for-two about the building, although the clock itself has been transferred to a position rather too exposed to observation to suit many couples.

We will ascend to the first floor by the staircase at the south-east corner of the South Court. A little additional light has been provided for this recently and was badly needed. It is now sufficient from the point of safety, but is evidently not intended to display the painted panels which are arranged on the walls. The particularly dark staircase at the north of the building

has now been closed, but many will remember the white statues at the head of it, vaguely discerned by day in the dim, religious light which penetrated the stained-glass windows, and which appeared at night as spectral guardians of the curtained entrance to the picture galleries.

We arrive on the wide balcony at one end of the South Court, which is devoted to cases of delicate ivory carvings. Unfortunately, no light has been provided for seeing these at night, although sufficient light is obtained from the arc-lamps in the centre of the court to admit of the gallery being used as a passage way and even to give some idea of the large frescoes by Lord Leighton which decorate the walls.

The lace-work galleries cross this one in the centre. The portion up the steps to the left is the bridge which crosses the old architectural court and, when it was filled with ironwork some two or three years ago, was lightless except for what it received through the arches from the arc lamps in the latter. When it became a thoroughfare on the opening of the new galleries it was lighted independently by a line of 100 c.-p. obscured, metallic-filament lamps, 10 ft. from the floor. These are 9 ft. apart, and the number might be increased with advantage, as some of the 6-ft. vertical case are insufficiently illuminated. A little might possibly be done by rearrangement, as, even in the daylight, there is frequently a "shady" side to a case.

The bridge across the South Court has two rows of clear 120-watt metallic-filament lamps at a height of 12 ft. Each row has eight such pendants, and, as the dimensions of the bridge are 90 ft. by 20 ft., more than a watt per square foot is used. A brilliant light is obtained, as might be expected, and in many circumstances such an allowance would err on the side of extravagance. In this case, however, there are no white walls to retain and reflect the light as the open iron-work and glass of the roof extend on either side. In addition the lamps hang at a fair height. It is from these pendants that a little extra light is obtained on the cases in the centre of the ground floor of the South Court, as previously mentioned.

Turning to the left, we reach the picture galleries. It has often been debated whether any useful purpose will be served by opening exhibitions of pictures to students after nightfall. The great body of opinion in the art world would seem to be against it, for neither the National nor Tate Galleries nor the Wallace Collection are provided with any artificial illuminant, and even the magnificent collection at the million-lamp lighted Franco-British Exhibition of 1908 was closed at sunset. However that may be, the Victoria and Albert Museum is the only picture gallery of the first class which is open at night in London, although the general practice in the provinces is opposed to that in the metropolis. The result is ample justification of this policy of the "open-door," for advantage is taken largely of the facilities afforded and students may be found any evening copying one or other of the works both in the arc-lighted galleries and even, *mirabile dictu*, in those served only by carbon-filament incandescents. Whether they are able to do their work with full satisfaction is another question. From the point of view of the general public, who like to see pictures either from curiosity or because they really enjoy looking at beautiful things in spite of having no trained artistic knowledge to guide their appreciation, there is little doubt that a picture gallery is little, if at all, less interesting because some nicety of colouring or shadow is omitted by lamp-light.

Two rooms are closed at present to be re-roofed. The next to these is No. 91, a small room 34 ft. by 20 ft., lighted by two 3-amp. arc-lamps. The illumination on the walls, and also in the desk-top cases of Dickens' manuscripts, is good, but the upright screens are poorly lit. The next rooms also have small arc-lamps in the centre, but these are not used. Instead, a rectangular wood frame is suspended at a height of 14 ft., and on this the lamps are fixed at a downward and outward angle so as to project all the light possible on to the walls. The frame is so constructed that its sides and ends

are parallel to, and 8 ft. distant from, the walls o' the room. 16-c.-p. obscured, carbon-filament lamps of 'mushroom' shape with silvered backs are used. There are forty-four of these fixed round the frame, eighteen along each side, and four at either end. The root principle of illumination, that the object to be examined must be lighted, and not the space around it, has been acted on, and the result is good, although possibly some economist may complain, in these days of metallic-filament lamps, that the current consumption for a room only 50 ft. by 25 ft. is unnecessarily high. This room is typical of four or five in which the light is concentrated on the walls at the expense of the centre area: unfortunately this area usually contains screens of pictures which are consequently in the shade.

In Gallery 94 the famous Raphael cartoons, lent by the King, are housed. Special glass to absorb the more harmful of the rays of light during the day has been used in the sky-light of this room. At night five large open-type arc-lamps are used, and the result is about equal to the day effect.

The four eastern rooms, 96 to 99, are each 45 ft. by 28 ft., and are lighted by two open-type 10-amp. arcs, 22 ft. from the floor. The pictures on the walls are well shown, but the screens are in shadow here also, as is inevitable with lighting points in the centre-line only of the gallery, but this is also the case to some extent by day. There is at times a very annoying unsteadiness of the arcs.

Finally, we reach the galleries of the Jones Collection, which, a year or two ago, were considered the best-lighted portion of the Museum. Since the opening of the new galleries and alterations to parts of the old section that opinion must be considerably modified. The collection is arranged in two parallel communicating galleries, each 105 ft. by 20 ft., and lighted by two rows of eight 5-light ball pendants in which 16-c.-p. lamps are used at a height of 13 ft. This gives a consumption of 2¼ watts per square foot, which should be ample. In the western gallery (101–2–3), which is filled with pictures and porcelain, all above the 4 ft. line, the illumination is sufficient, although it might be improved by slightly lowering the lamps, and, if these are provided exclusively for displaying the objects, this ought to be done. It is possible, however, that it is intended to show the artistic decorations of the rooms as well as their contents, and, if this is the case, a little additional lighting is desirable.

In the eastern gallery (104–5–6), the exhibits are principally furniture, cabinets, &c., which extend to as low as a foot from the floor, and are rather crowded together. The lower parts of these are very poorly lighted, and the pendants should certainly be dropped considerably and the candle-power increased somewhat. The effect is certainly much inferior to that of the daylight through the glass roof.

Bearing in mind the excuses which may be urged for defects and remembering the alterations which have been recently, and are still being, carried out, we can hope that, like London, the museum will be "a foine place when it's finished."

The Institution of Mechanical Engineers.

Joint Summer Meeting, 1910.

We note that, as previously announced, a joint meeting of the American Society of Mechanical Engineers and the Institution of Mechanical Engineers (British) is to be held in the summer of this year.

The proceedings will open on Tuesday, July 26th, with the reception of the presidents of the respective societies by the Lord Mayor of Birmingham, and a programme of papers, visits, and social events, has been arranged for this and the two succeeding days. Subsequently the members of the American Society will be entertained in London. The Conversazione is to take place on Thursday, July 28th, and the Institution Dinner on July 29th.

Further particulars can be obtained from the Secretary of the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.

Notes on the Testing of Incandescent Mantles, Electric Glowlamps, and Arclamps, &c.

By an Engineering Correspondent.

(The following notes are taken from a revised copy of a paper which secured the "Durham Bursary" for 1909-1910, and are published by the kind permission of the Junior Institute of Engineers. The paper in question also contains a summary of the principles of light-production, historical notes on the development of different methods of lighting, and a discussion of photometers, &c., which, however, will be familiar to readers of this journal from previous articles on these subjects. It is interesting to note that a paper devoted to the discussion of Illumination as a whole should have been awarded the Bursary referred to, and this may be regarded as one more instance of the growing desire to stimulate investigations on all matters connected with illuminating engineering.)

The intensity of the light of a source can be expressed in several ways, the method of measurement greatly depending upon its nature and use. In many cases, owing to ignorance as to the form of light distribution from a source, electric lamps, gas mantles, &c., are wrongly situated for the purpose required. As the result, more power is needed to produce a given illumination, with consequent extra expense.

The measurements usually taken of ordinary sources of gas or electric light are :—

(*a*) Mean Spherical Intensity.
(*b*) Mean Hemi-spherical Intensity.
(*c*) Mean Horizontal Intensity.

Measurement of Light in a Single Direction only.

In some cases, such as limelight, in which the candle-power in the direction of the greatest intensity is mainly required, the candle-power is usually determined in that direction only, and the pressure of gas varied so as to obtain the most economic conditions.

The following table gives a series of tests with limelight, using an oxy-acetylene flame, from which it will be seen that very high candle-powers can be obtained.

Generator used.	Jet used.	Oxygen Pressure, lbs. per sq. in.	Candle-power obtained.
Low Pressure	No. 1	10	1230
		15	2150
		20	2440
,,	No. 2	15	2790
		15	2280
Higher Pressure	Smaller Orifice	10	1360
		15	2010
		20	2440
,,	Larger Orifice	15	2150
		20	2520

Polar Curves of Light Distribution.

To determine the mean spherical or hemi-spherical intensity of a gas mantle, a radial photometer is required, as the burner must be held in a vertical position during all measurements. Fig. 1 shows the polar curves of both the upright and inverted type of mantle, from which it will be seen the advantage the inverted mantle possesses as regards light distribution ; both mantles have approximately the same consumption.

Electric glow-lamps are usually most convenient for making photometric tests, since they are easily fixed to the photometer bench by means of an ordinary holder, and can be turned into any position.

Figs. 2, 3, and 4 show the polar curves of different lamps, from which the spherical or hemi-spherical intensity can easily be determined by the usual process of projection.

Life Tests.

Life tests on electric lamps and gas mantles approximately determine the period for which they can be used efficiently, but the usual conditions under which life tests are made differ considerably from those experienced in practice, and the life of a gas mantle, or of a metal filament lamp, before losing its efficiency in candle-power, is often terminated by breakage.

The following figures have been supplied by the Gas, Light & Coke Co. of tests made 16th June, 1909, at their laboratories :—

Mantles from Stock after Burning 24 hours.

Description.	Pressure in inches.	Consumption per hour (cub. feet).	Illuminating power.	Candles per (cub. foot).
A	17/10	3·95	78·6	19·9
B	,,	,,	78·6	19·9
C	17/10	3·95	78·6	19·4
D	,,	,,	,,	
E	,,	4·0	77·6	19·4
F	20/10	5·35	113·0	21·1
G	,,	5·25	110·0	20·9
			Average	20·0

(*To be continued.*)

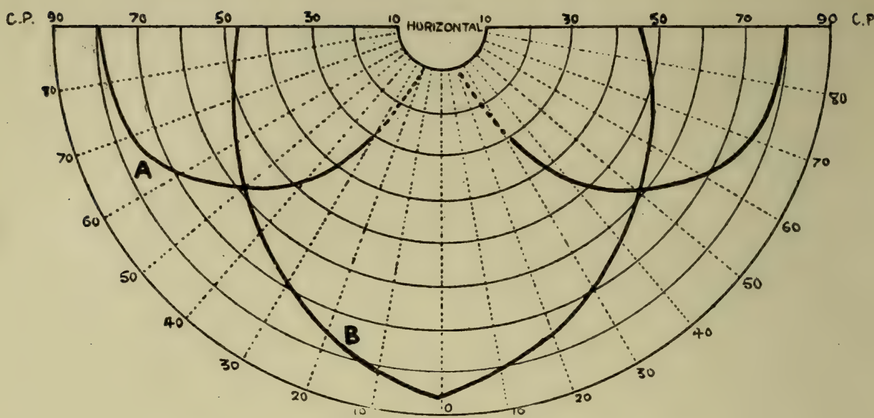


Fig. 1.—A. Upright Incandescent Gas Burner.
Mean Hemispherical Candle Power=37.

B. Inverted Incandescent Gas Burner.
Mean Hemispherical Candle Power=68.

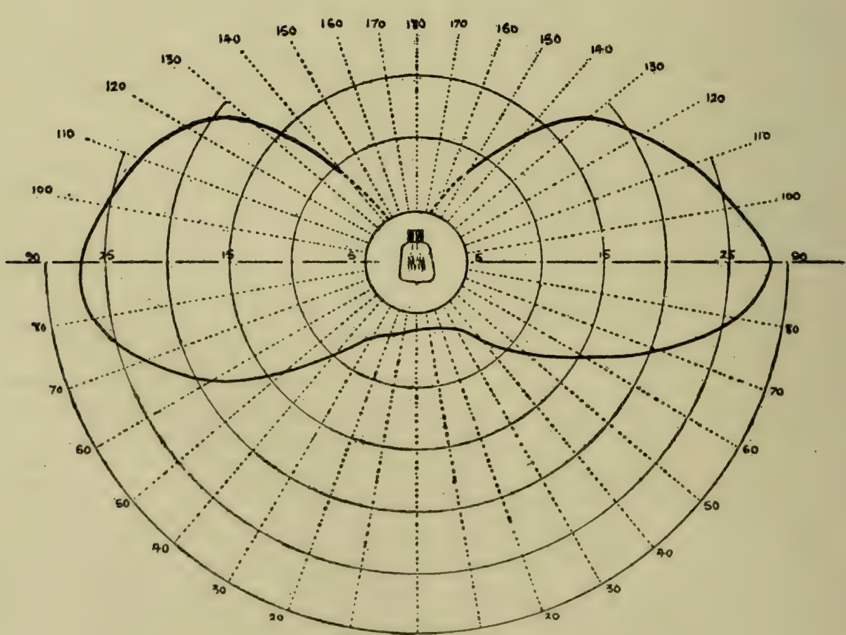


Fig. 2.—Tantalum Lamp.
100 volts, 0·44 amperes. Mean Hemispherical Candle Power=11·8.

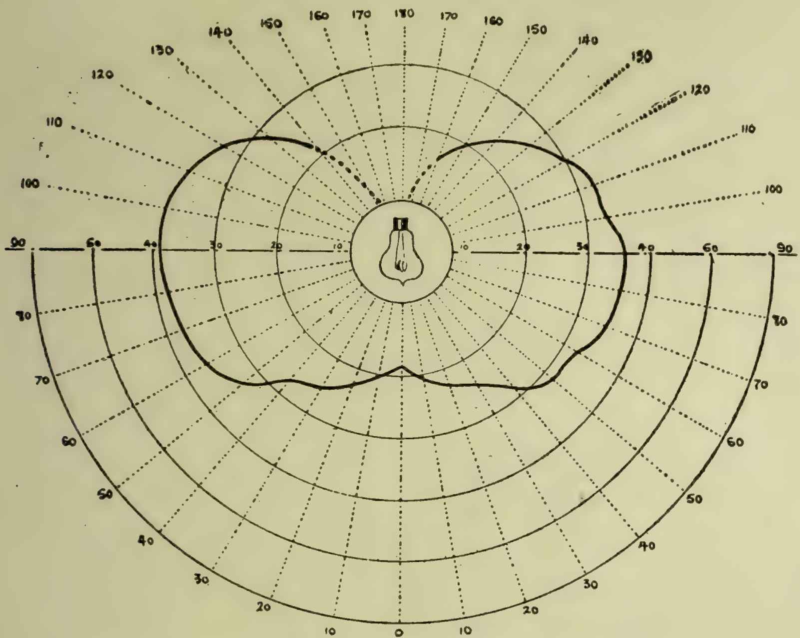


Fig. 3.—Carbon Filament Lamp.
100 volts, 0·95 amperes. Mean Hemispherical Candle Power=27·6.

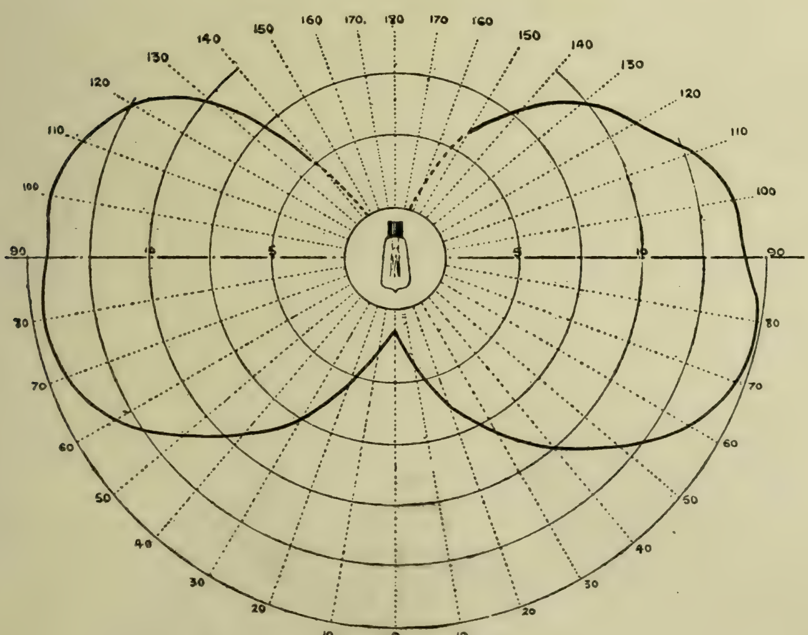


Fig. 4.—Osram Lamp.
50 volts, 0·36 amperes. Mean Hemispherical Candle Power=9.

The Illumination of Interiors.

(A series of three lectures delivered by Prof. J. T. Morris, M.I.E.E. and Prof. C. A. M. Smith, B.Sc the East London College, on June 8th, 15th, and 22nd.)

THREE lectures on the above subject were delivered at the East London College (University of London) on Wednesdays, June 8th, 15th, and 22nd respectively. The first two, by Prof. J. T. Morris, M.I.E.E., dealt with (1) 'Principles and Daylight Illumination,' (2) 'Artificial Illumination by Gas and Electricity'; the third, by Prof. C. A. M. Smith, B.Sc., was devoted to 'Illumination by Petrol Air-Gas.'

In opening the first lecture Prof. Morris remarked upon the importance of having lights situated so that the direct rays could not enter the eye. This was demonstrated by some simple but instructive experiments.

After discussing some of the incorrect methods of illumination caused by people's lack of knowledge of the subject, the lecturer proceeded to point out some interesting facts in connexion with daylight and its variations. Observations taken in the grounds of the East London College on June 7th (an average bright day) showed that at 1.30 P.M. the intensity of illumination was approximately 3,500 candle-feet. On the sun becoming obscured for a short time the intensity dropped to less than one-third of this value, while at 6.30 P.M. it was only 170 candle-feet. By 9 o'clock the intensity was not much more than 1-20,000th of the mid-day value. When the arc-lights were put on the value rose to 0·1 candle-foot.

Turning next to the relation between the illumination inside a room and the intensity of illumination outside, Prof. Morris mentioned as a remarkable fact that only about one-hundredth to one-thousandth of the outside intensity found its way into the average room. In this connexion the lecturer exhibited a table, compiled by Mr. P. J. Waldram, showing the value of this ratio in the case of several well-known buildings throughout London. For example: on desks in a new elementary school, 0·0025 to ·008; ordinary offices, average 0·001; House of Lords (woolsack), 0·006; Charing Cross Station, booking hall, 0·0001 to 0·0003. It is interesting to observe that this ratio remains fairly constant throughout the day, and is, seemingly, more or less independent of climatic conditions.

It will thus be seen that there are wide fluctuations continually taking place in the light of which we are more or less unconscious. In explanation of this the lecturer explained how the pupil of the eye expands and contracts with variation in intensity of incident light. This point was illustrated by curves showing the result of tests made at the East London College. These curves illustrated the connexion between the area of the pupil aperture and the illumination; a very sharp bend in the curve occurs when the illumination is reduced to a certain value below one foot-candle. The effect of light entering the eye obliquely was also shown.

Most of the experiments on intensity were made with a Trotter Universal Photometer equipped with the special daylight attachment. The principles and action of this instrument were explained by the lecturer and have been described by Mr. P. J. Waldram in this Journal.* Prof. Morris also pointed out how much there remained to be learned on this subject, although a marked impetus to researches in this field had been given by the formation of the Illuminating Engineering Society. When the Society was first founded, he confessed that he had been among those who were not altogether convinced as to its utility; but he had since come to appreciate the importance of its impartial attitude and the work it proposed to carry out, and he was now thoroughly convinced of the useful field before it.

In his second lecture Prof. Morris

* *Illum. Eng.*, Lond., Vol. I., 1908, p. 811.

continued his discussion of the measurement of daylight illumination. Referring to the arrangement for measuring the ratio between the interior and outside unrestricted sky-illumination, he pointed out that the brightness at different parts of the sky varied considerably. This difference could be very readily studied by the aid of the Trotter daylight attachment, and Prof. Morris exhibited a table illustrating the manner in which the intensity varied from the zenith to the horizon. In using the Trotter daylight apparatus the result obtained must, therefore, be regarded as to some extent arbitrary, though, as stated above, the ratio connecting the indoor illumination with unrestricted sky-illumination outside did remain very constant in spite of fluctuations in climatic conditions. Attempts had been made to ascertain the ratio of the intensity at the zenith and to the average intensity; it appeared to be about 5 to 1.

Turning next to artificial illumination the lecturer pointed out one fundamental distinction between gas and electric lighting, namely, that whereas the nature of the electric current was quite definite, the quality of gas supplied varied in different localities. In testing a Keith high-pressure burner a difference of over 50 per cent. in the candle-power was obtained between measurements made in East London and North London. It is, therefore, particularly important that steps should be taken to see that consumers get a definite calorific value.

The leading systems of electric lighting were also briefly touched upon and some comparative figures given for different types of lamps. The Moore vacuum tube lamp was specially noticed owing to its exceptionally low intrinsic brilliancy. Figures were given showing the intrinsic brilliancy of various sources. A few examples are: Sun, 100,000 c.-p. per square cm.; arc, 16,000; tungsten lamp, 150; carbon filament, 16; high-pressure gas, 25 candle-power per sq. cm.

In passing, the lecturer remarked that he, personally, was not concerned exclusively with the advantages of any one method of lighting, and desired to examine each one on its merits and to preserve an entirely unbiassed and judicial attitude.

A series of remarkable curves, which had been obtained from measurements taken by the lecturer, were then presented showing the fluctuation of light on the leading electric railways and tramways of London. On "the Circle" a variation between about 0·8 candle-feet and over 2 candle-feet was noticed. A comfortable reading illumination in trains is 1 candle-foot. The advantages of metallic filament lamps on variable voltage supply was well illustrated in one case in which both these and carbon lamps were used on the same railway. As was to be expected, the variations on trams were much more marked.

The lecturer next turned his attention to shades and reflectors, and exhibited some of the scientifically designed shades manufactured by the Holophane Co. Prof. Morris also expressed a strong opinion that street lamps should always be so shaded that the source of light could not be seen. He characterized the lighting of Whitehall as magnificent as regards intensity of illumination, but faulty from the standpoint of excessive glare.

The lecturer also remarked that there was a general impression that for interior lighting the nearer the lamp the better the illumination. The fallacy of this was well exemplified by curves showing the intensity of illumination over a floor with an arc lamp at two different heights. Lowering the lamp actually decreased the light where it was most required.

On the occasion of the third lecture on 'Illumination by Petrol Air-Gas,' Prof. Smith arranged for the exhibition of plants manufactured by four of the leading makers; these were shown in actual operation during the lecture. By way of introduction the lecturer remarked that the question was attracting much attention at the present time, and many rash statements were being made both for and against petrol air-gas. He thought, however, from experiments he had made that, generally speaking, a fair case could be made out for air-gas without resource

to the obviously absurd statements made by some enthusiasts.

Air-gas is the name given to a mixture of some inflammable vapour and air. The liquid generally employed is petrol, but he thought that there was probably scope for the use of benzol in the future.

The principle, though simple, is difficult to apply, the following points being of primary importance: (1) Carburation must be constant. (2) Apparatus must be self-regulating and capable of giving a constant mixture under all circumstances. (3) The mixture must be intimate. These principles are rendered difficult owing to the fact that petrol is a mixture of liquids, and also that temperature has a very marked effect on the vapourising properties. This point was discussed at some length by the lecturer and exemplified by curves obtained from theory and practical experiment.

In comparing the cost of air-gas and coal-gas, from the standpoint of a given heat-production, a difficulty is immediately encountered, namely, the fixing of a proper value for the calorific value of coal-gas. It would appear, however, that heat unit for heat unit petrol at 10*d*. per gallon is equivalent to coal-gas at 3*s*. 9*d*. per 1,000 cubic feet (630 B.Th.U.s) or at 2*s*. 10½*d*. (480 B.Th.U.s). When tested for light, so far as it had been possible to determine by experiments at the College, air-gas seemed to give a greater efficiency than coal-gas, the cost per 1,000 candle-power hours coming out at from 1¼*d*. to 2¼*d*.

A description was then given of some of the different plants employed, starting from the earliest apparatus up to the modern machines exhibited on this occasion. Most modern machines consist in general of the following essential parts:—(1) Some source of power, generally a hot-air engine or falling weights to provide the necessary power for pumping the gas through the mains. (2) A pump, generally in principle similar to a reversed wet gas-meter. This pumps air through (3) a carburettor to which petrol is supplied. The gas then passes into (4) a gas reservoir or "gasometer," the rising and falling of which controls the making of the gas.

Some machines have means of measuring out the air and petrol in definite quantities, others rely on automatic contrivances for keeping the mixture constant.

The mixture formed is about 1½ to 2½ per cent of petrol vapour to 98½ to 97½ per cent of air. Such a mixture is non-explosive, hence the claim by the makers of it being safety gas.

The lecturer concluded by pointing out the great need of an opportunity for careful research on many undecided points in connexion with air-gas machines. For example, one would like to know what was the best pressure to utilize at the burner. The use of pressures considerably exceeding the 2 in. of water which was at present customary would involve the use of specially designed burners, but it might be worth while to take this trouble in order to obtain increased efficiency. Speaking as one who took an entirely unbiassed attitude towards the various methods of lighting now available, there certainly seemed to be special advantages enjoyed by the variety of illuminant he had been describing, but there was still considerable room for improvement, and he felt sure that makers of air-gas plants would welcome reliable data on the problems on which they were engaged.

New Books.

Colour Blindness and Colour-Perception, by F. W. Edridge Green, M.D., F.R.C.S. (Kegan Paul, Trench, Trübner & Co.), 5/.

Illumination and Photometry, by W. E. Wickenden, B.S., Asst. Professor of Electrical Engineering, Massachusetts Institute of Technology, U.S.A. (Hill Publishing Co., Ltd., 6, Bouverie Street, London, E.C.).

We propose to refer in greater detail to these two works shortly.

CORRESPONDENCE.

Mr. Abady's Street Lighting Contract.

Sir,—There are several points in connexion with the contract on street lighting recently described by Mr. Abady in his paper before the Institution of Gas Engineers on which I should like to comment.

I hold that, at the present time, it is very essential that any specification of this kind, while allowing ample margin on debatable points, should at least contain clear and definite instructions on such matters as it does attempt to treat. It may be added that a mere scientific flavouring in contracts of this nature, is in itself not only of no value, but distinctly misleading unless the meaning is perfectly clear and definite. The contract described by Mr. Abady does seem to me needlessly rigid in some respects, and not sufficiently explicit in others.

What, for example, is the object in stating that the photometer must work on the inverse square law? Does this merely mean that the candle-power of the source must be calculated by this method from a knowledge of its distance away? Or does it mean that the mechanism of the photometer is to be based on the inverse square law, *i.e.*, that the illumination of the photometer-screen must be varied by moving the comparison lamp to and fro? It is difficult to see why the latter point should be insisted upon and Mr. Abady's own street photometer, as exhibited at a recent meeting of the Illuminating Engineering Society, was not constructed to utilize this principle. If, however, all that is meant is that the illumination should be calculated in this way, there is still the objection that a lamp containing several mantles and a relatively short distance away from the photometer cannot be regarded as "a point source." No question of this kind could arise were the *illumination* measured, since in that case we are only concerned with the production of a given illumination irrespective of the distance away from the source.

Again, what is meant by the requirement that the photometer shall "read accurately whatever the respective colours of the light under test, and standard light." Does this imply that the photometer is to be of the flicker pattern, or that a particular make of instrument is to be employed? If so, it can only be said that, in view of the differences of opinion on this point among authorities in different parts of the world, some of whom are by no means convinced as to the correctness of the flicker principle, it seems an undesirable restriction to insist upon the use of a photometer of this special type. On the other hand, if the meaning of the phrase is only vague and general, of what value is it? For who is to decide when a photometer reads accurately irrespective of the colours of the lights tested?

Again the suggestion that the mean of the reading at angles of 20 degrees and 50 degrees represents the mean hemispherical candle-power of any lamp, although attractive for its simplicity, would certainly seem to be one which demands more exact study before it can be relied upon, especially in view of the considerable amount of work that nas been done on this question without any such law having been discovered. This is, however, an interesting suggestion if further investigation will bear it out.

As explained above, it does not seem necessary or desirable to specify strictly the exact type of instrument to be used. But it *is* necessary that the instrument, of whatever make it may be, should have a satisfactory degree of accuracy. What order of accuracy is demanded in this case? And who

is to check the instrument and ascertain whether it possesses the requisite qualifications in this respect ? The contract merely states that the photometer should "read accurately" !

Further, it is stated that "the light shall be of a steady invariable character of a white or yellowish white colour." In this short sentence there are endless possibilities of dispute. How can any one know what is implied by a "steady" light unless the steadiness is defined and a certain method of testing the variation of candle-power of a source within a given period is specified ? And what is the object in directing that measurements should be made at intervals of not less than 30 or more than 60 seconds ? Is this intended to test the steadiness, and would the measurements be invalidated if not made at the prescribed intervals ?

It is equally impossible to judge by the naked eye only when a light ceases to be yellowish white and becomes yellow unless these colours are properly defined. One's impression as to the colour of light varies very considerably according to the previous history of the eye, and so many shades of colour in modern illuminants exist intermediate between the bluish white of the enclosed arc lamp and the most strongly yellow-tinted flame arcs, that it is difficult to draw a precise line as to what is *yellow* and what is *white*. In addition the impressions of individuals differ. Have we, then, to test the operators for colour blindness before authorizing them to test ? No doubt a sufficiently rigid definition and a method of testing on scientific lines could be devised. Even so decisions on this point would certainly lead to dissatisfaction and who is to decide in the event of a dispute ?

To mention yet another possible source of uncertainty, I should like to enquire whether the failure of a lamp to give the requisite candle-power, *for any cause whatever*, is to involve a penalty. Suppose, for example, a mantle or lantern is inadvertently broken while tests are being made ; is the inevitable reduction of light before it can be repaired sufficient ground for complaint against the company ? I am, yours, &c.,

A Ratepayer of Westminster.

Low Voltage Streetlighting.

The Electrical World of New York for June 9th, 1910, records a new method of street lighting to be employed in Vancouver, British Columbia, which is somewhat novel. The lighting of the streets is to be accomplished by means of standards about ten feet high each of which will be equipped with a cluster of five 75-watt tungsten lamps, enclosed in frosted glass globes. At the base of each standard will be a transformer which will reduce the pressure to 11·3 volts. In this way all the advantages of their stoutness and durability of low-voltage filaments will be secured and it is anticipated that any possible trouble in the shape of breakage of filaments through the vibration of passing vehicles will be completely avoided.

Novel Scheme for Illuminating a Banquet Hall.

The Electrical Review of New York (May 28) describes a somewhat novel system of lighting employed in New Jersey on the occasion of the President of the United States paying a visit to the city.

The Town Hall in which the banquet took place was converted into an Italian Pergola by means of a false framework on the ceiling ; to this were attached branches of artificial apple blossom. The illumination was provided by two long tubes of the Moore light, one encircling the pergola and the other supported from the edge of the balcony. Each of these tubes was 150 ft. in length and $1\frac{3}{4}$ in. in diameter. The tubes were filled with nitrogen, and the resultant rose yellow tint of the illumination is said to be very effective.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

A paper of considerable interest is that read by **J. Abady** at the Annual Meeting of the Institution of Gas Engineers dealing with PUBLIC LIGHTING FROM THE MUNICIPAL STANDPOINT. The author criticizes three different types of contracts on street lighting, and expresses his preference for one based on the provision of a minimum candle-power on the part of the sources installed. As an illustration he quotes a section of the contract recently entered into between the Westminster and City Council and the Gas Light and Coke Company.

Street lighting is also indirectly touched upon in a paper by **C. H. Sharp**, read before the Illuminating Engineering Society in the United States. The author describes a special form of METALLIC REFLECTOR intended to concentrate the light for the street instead of allowing it to escape upwards and sideways.

Among other items in the United States special reference may be made to the announcement of the COURSE OF LECTURES IN ILLUMINATING ENGINEERING to take place at the Johns Hopkins University in Baltimore. This is to follow immediately the Convention of the Illuminating Engineering Society, and many of the leading authorities in the United States will lecture on their respective subjects. We may also notice several interesting articles which have appeared in *The Illuminating Engineer* of New York for June. One of these deals with HOSPITAL LIGHTING. A number of illustrations are presented showing wards in which the arrangements with regard to illumination were very unsatisfactory, specially on account of non-avoidance of glare. Other articles deal with FIXTURE DESIGN. A new variety of ornamental semi-translucent glass fixtures is described, and the question is also raised why is it that fixtures are so constantly sent out without the name of their designer being known. Another article describes the lighting arrangements in the home of Mr. Andrew Carnegie. **H. E. Ives** (*T.I.E.S.* for February, 1910) contributes a paper on LUMINOUS EFFICIENCY, in which he summarizes recent work in this field.

Attention may also be drawn to the lectures delivered by **Prof. J. T. Morris** at the East London College which are referred to in various technical journals. Two points of special interest in these lectures were the presentation of a series of curves connecting the size of the pupil aperture of the eye with illumination under various conditions, and some diagrams showing the FLUCTUATIONS IN ILLUMINATION ON THE UNDERGROUND RAILWAYS in London.

ELECTRIC LIGHTING.

As usual a number of articles deal with the metallic filament lamps. Chief among these may be mentioned a paper by **S. E. Doane** before the National Electric Light Association in the United States; in this the author analyzes the EFFECT OF HIGH EFFICIENCY LAMPS ON CENTRAL STATION REVENUE, taking a hopeful view of the situation.

L. G. Spinney (*Elec. Rev.*, N.Y., June 4) presents a series of diagrams illustrating the average FLUCTUATION IN VOLTAGE ON SUPPLY CIRCUITS and the resultant variation in illumination. **K. Kiel** (*E.T.Z.*, April 28) discusses the SORTING OUT OF GLOW-LAMPS BY VOLTAGE AND CANDLE-POWER—always a rather tedious process owing to the fact that each lamp has to be handled separately. He suggests a modification of the existing methods based on the use of a curve, correcting the chief electrical characteristics of a given make of lamps. **W. W. Coblentz** (*Elec. World*, N.Y., May 19) contributes a note on the EMISSIVITIES OF METALLIC FILAMENTS, tracing the connexion between the selective action of metals as regards radiation of light and their reflecting power in different portions of the spectrum.

Among other articles on glow-lamps we may note those in recent numbers of the *Zeitschrift für Beleuchtungswesen* dealing with a suggested improved method of arranging glow-lamp holders. The author advocates the use of fairly thick and durable glass as an insulator, and describes an arrangement enabling a glass shade to enter direct into the holder and form a substantial barrier between the metallic parts connected to the positive and negative parts of the circuit. A second article describes a method of clamping filaments in position and rapidly measuring their resistance.

W. Wedding (*E.T.Z.*, May 19, 26) gives an exhaustive account of some

researches into the behaviour of the Moore Tube. He describes investigations of the phase relations between the P.D. and current, and the effect of introducing self-inductance into the primary circuit. He also makes a study of the efficiency of the tube, and finds it practically identical with that of a number of tantalum lamps producing an equivalent illumination.

W. K. Miller (*Popular Electricity*, June) describes the Quartz Tube Mercury Lamp, which is now being utilized in the streets of Paris in units of 1,000–2,000 candle-power. He remarks on its low intrinsic brilliancy—in which respect it compares favourably with other of the brilliant modern illuminants.

Lastly, attention may be drawn to the account of the Convention of th National Electric Light Associatio which is given in several of the technical journals in the United States.

GAS, OIL, ACETYLENE LIGHTING, &c.

One of the most important items of the past month has been the Annual Meeting of the Institution of Gas Engineers (London). The majority of the matters discussed, however, dealt with gas technicalities rather than with illumination. The paper on street lighting contracts by **J. Abady,** however, was exceptional in this respect, and is referred to under the heading of 'Illumination.'

The Presidential Address contained references to several points of considerable importance though only touching indirectly on illuminating engineering proper. The suggestion of an ultimate calorific standard for gas received emphatic support, and the President had also something to say regarding the changing conditions in the gas industry and the need for concerted action. A somewhat striking proposal was his suggestion that the range of membership of the Institution of Gas Engineers should be extended, and that the name of that body should be altered to "The Gas Institute" in order that commercial men might take a more active part in its proceedings.

One exhibit which much interested the visitors to London on the occasion of this meeting was the series of new 4,500 c.-p. (nominal incandescent, lamps just installed in Aldwych. It is stated that, in order to compensate for any possible drop of pressure in the mains, and also to allow for the possibility of the calorific value of the gas supplied being lower than that which the nominal candle-power of these lamps demands, gas will be fed to the public mains in this neighbourhood at a pressure of 70 to 80 inches. This is certainly a pressure that would hardly have been anticipated a few years ago!

We have again to note several articles dealing with Distance Gas Lighting. **F. Göhrum** (*J.f.G.*, May 28) sums up lucidly the chief requirements to be met by apparatus of this kind, and also its main advantages. **H. Dobert** (*J.f.G.*, June 18) sets out to consider whether the saving theoretically made by using distance lighting devices can be actually realized in practice. His decision is favourable.

Prof. C. A. M. Smith recently delivered a lecture on Petrol-Air Gas at the East London Technical College. The lecture was of a general character, dealing mainly with the principles of the subject. The lecturer pointed out the need for scientific research and the numberless details which still called for careful study. For example, one would like to know exactly what was the most suitable pressure for burners utilizing this gas. It was also pointed out that users of petrol for incandescent lighting had at least the satisfaction of employing a fuel of fairly constant calorific power, whereas the calorific power of gas used in different localities varied considerably.

There are several papers reported in the United States technical press dealing, on general lines, with Shop Lighting by Gas and other subjects. Also the usual notes in the *Zeitschrift für Beleuchtungswesen* describing New Types of Inverted Burners, and burners for use with various kinds of liquid fuel.

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*

E. T. Z.—*Elektrotechnische Zeitschrift.*

G. W.—*Gas World.*

Illum. Eng., N.Y.—*Illuminating Engineer of New York.*

J. G. L.—*Journal of Gaslighting.*

J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*

Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

ILLUMINATION AND PHOTOMETRY

Abady, J. Public Lighting from a Municipal Standpoint (Paper read before the Inst. of Gas Engineers, *G. W.*, June 18 ; *J. G. L.*, June 21 ; *Elec. Engineering*, June 16).
Black, N. M. Alternating Illumination (*Illum. Eng.*, N.Y., June, 1910).
Editorial. The Luminous Efficiency of Incandescent Lamps (*Elec. World*, N.Y., May 19).
Illuminating Engineering (*Elec. World*, N.Y., June 2).
The Study of Illumination (*Elec. Rev.*, N.Y., June 11).
Government Regulation of Illumination—Public Education—Free Advertising, &c. (*Illum. Engineer*, N.Y., June, 1910).
Reflectors for Street Lighting (*Electrician*, June 17).
Incandescent Lamps as Standards—Photometric Units and Nomenclature (*Elec. World*, June 16).
Högner, P. Methode zur Berechung der Vertikalflächnenbeleuchtung und der Horizontalflächenbeleuchtung (*E. T. Z.*, June 9).
Hough, W. The Development of Illumination (*Illumination*, April, 1910).
Ives, H. E. Luminous Efficiency (*T. I. E. S.*, Feb., 1910).
Macallister, S. A. The Bearing of Reflection on Illumination (*Elec. World*, May 26).
Morris, Prof. J. T. The Illumination of Interiors (*J. G. L.*, June 21, lectures delivered at the East London College, June 8 and 10).
Rosa, Dr. E. G. Photometric Units (*Elec. World*, N.Y., June 16).
Sharp, C. H., and Millar, P. S. Incandescent Lamps as Standards of Luminous Efficiency (*Elec. World*, N.Y., June 16).
Sharp, Dr. C. H. A New Efficiency Reflector for Street Lighting (paper read before the Illuminating Engineering Society, U.S.A., May 12).
Illuminating Engineering Society, Annual Meeting (*G. W.*, May 28).
The Johns Hopkins Course in Illuminating Engineering (*Elec. World*, N.Y., June 2; *Elec. Rev.*, N.Y., June 11).
The Quality of Light (*J. G. L.*, June 21).
Hospital Lighting (*Illum. Engineer*, N.Y., June).
The Light of the Immortals (*Illum. Engineer*, N.Y., June).
The Aristocracy of Art (*Illum. Engineer*, N.Y., June).
The Measurement of Light and Illumination (*Am. Gaslight Journal*, May 10).

ELECTRIC LIGHTING.

Auerbacher, L. T. Construction and Operation of an American Flaming Arc-lamp (*Elec. Rev.*, N.Y., May 21).
Coblentz, W. W. The Emissivities of Filaments considered from the Standpoint of their Reflectivities (*Elec. World*, N.Y., May 19).
Doane, S. E. High Efficiency Lamps and their Effect on the Cost of Light to the Central Station (paper read before the Nat. Elec. Light Association, May 23, 1910).
Editorials. The Development of Elec. Lighting (*Elec. Rev.*, N.Y., May 21).
Kiel, K. Ein vereinfachtes Verfahren zum Sortieren von Glühlampen (*E. T. Z.*, April, 28).
Perkins, F. C. Lampe à arc sous-marine (*L'Electricien*, May 28).
Spinney, L. G. Regulation and Illumination (*Elec. Rev.*, N.Y., June 4).
Tiersot, L. Verification du vide dans les lampes à incandescence (*L'Electricien*, May 28).
Miller, W. K. The First Carbonless Arc Lamp (*Popular Electricity*, June, 1910).
Wedding, Prof. W. Das Moore Licht (*E. T. Z.*, May 19, 26).
The use of Phospham in Metallic Filament Lamps (*Elec. Engineering*, June 16).
The Convention of the National Electric Light Association (*Elec. Rev.*, N.Y., May 28).
Twenty-five Years of the National Elec. Light Association (*Elec. Rev.*, N.Y., May 21).
Modern Lamps and Lighting Systems (*Elec. World*, N.Y., May 19).
Annual Convention of the National Electric Light Association (*Elec. World*, N.Y., June 2).
Die neue " Elec. Lighting Act " (*E. T. Z.*, May 19).
Glühfaden-Messinstrument (*Z. f. B.*, June 10).
Fortschritt im Bau von Glühlampen-Armaturen (*Z. f. B.*, June 20).
Flame Arc Lamps—Carbon Deposit (*Elec. Rev.*, June 10, 17, 24).

GAS, OIL, ACETYLENE LIGHTING, &c.

Dobert, H. Savings accomplished by Distance Gaslighting (*J. f. G.*, June 18).
Göhrum, F. Gasdrückfernzündung (*J. f. G.*, May 28).
Kelley, E. F. Gas Arcs and Factory Lighting (*J. f. G.*, May 28).
Luckerath, O. Pressgasbeleuchtung in Charlottenburg (*J. f. G.*, May 28).
Smith, C. M. Petrol Air Gas Lighting (Lecture delivered at the East London Technical College, June 15).
Young, R. R. The Future of Gas for Store Lighting (*Am. Gaslight Jour.*, June 13).
L'Acetylene appliquè aux Illuminations d'églises (*Rev. des Eclairages*, May 30).
British Acetylene Association, Annual Meeting (*Acetylene*, June, 1910).
Institution of Gas Engineers, Annual Meeting (*J. G. L.*, June 21 ; *G. W.*, June 18).
Large Candlepower High Pressure Units on View in London (*J. G. L.*, June 21).
Neue Invertbrenner....Glühlicht für flüssige Brennstoffe, &c. (*Z. f. B.*, June 10, 20).

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Catalogues Received.

ARC-LAMPS FOR LANTERNS, CINEMATOGRAPHIC, AND PROJECTION APPARATUS.

A list issued by the *Stralsunder Bogenlampenfabrik* (*Stralsund, Germany*) contains particulars of a variety of cheap forms of lamps for lantern work, the "Kispar" being a projection lamp, with inclined carbons specially intended for cinematographic work. Also prices of transformers, resistances, &c.

FITTINGS FOR INCANDESCENT GAS.

We have before us a little list of fittings for incandescent gas issued by *Messrs. W. A. S. Benson & Co., Ltd* (*82–83, New Bond Street, London, W.*), in which a number of original decorative designs in antique styles are shown. We understand that particulars of new designs of this nature will be available shortly.

ELECTRIC GLOW-LAMPS.

Messrs. Siemens, Bros., Ltd. (Tyssen Street, Dalston, London, N.E.), send us a new price list C5, embodying the reduced prices of TANTALUM LAMPS as mentioned in our last number, and giving particulars of voltages, C.P.'s, sizes of bulbs, &c., of all types of Tantalum Lamps now on the market. Copies can be obtained on application to the above address.

The British Thomson Houston Co., Ltd. (*Rugby*).—Price List No. 244 relating to MAZDA tungsten lamps. For these lamps a specific consumption of 1·25 to 1·5 watts per candle is quoted. Specially marked lamps for series burning are available. It is interesting to observe that the marking of these lamps serves to indicate when two lamps can be satisfactorily "paired."

The British Westinghouse Co. (*Manchester*).—The AURIGA lamps, stated to possess an efficiency of 1·25 watts per Britich c.-p., now available at reduced prices. The list concludes with a serios of instructions to users.

ACETYLENE FOR LIGHTING AND COOKING.

From *W. Güntner* (4, *Liebhartsgasse, Vienna*) we receive a description of acetylene incandescent burners. For these a consumption of 0·25 litres per candle-power is claimed. Special methods are adopted to prevent the possibility of back-lighting, smoking, &c. Incandescent burners using 5, 10, 15, 20, and up to 50 litres per hour are available.

VARIOUS.

Electric Fans and Heating and Cooking Apparatus (*The Ediswan Co.* (*Ediswan Buildings, Queen Street, E.C.*). 'Arctic Fans (*Julius Sax & Co., Ltd., 24A, High Street, New Oxford Street, London, W.C.*). Alternating Current Squirrel Cage and Slip Ring Induction Motors, *The British Westinghouse Electric Manufacturing Co., Ltd.* (*Manchester*). Flexible Reversible Couplings, *The Power Plant Co., Ltd.* (*West Drayton, Middlesex*). Lists of the *Cape Asbestos Co., Ltd.* (*23, King Street, London, E.C.*). Hauling and Agricultural Machinery (*H. Lewis & Sons, Reading*). Water Softening Apparatus (*Bowes Scott & Western, Ltd., Westminster, London, S.W.*). Insurance and Upkeep of Machinery (*Messrs. Marryat & Place, 28, Hatton Garden, London, E.C.*).

The ILLUMINATING ENGINEER

· ELECTRICITY · ACETYLENE · OIL · GAS ·

Edited by LEON GASTER

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EDITORIAL.

Lighting Literature in the Daily Press.

We have frequently been struck by the increasing number of articles, dealing with matters of illumination, which now appear in the daily and non-technical press. In principle we welcome the popularization of information on lighting. Almost everyone, whatever his occupation, is more or less concerned with the use of light, and it is only natural that there should be a demand for readable literature on the subject.

A considerable number of the articles of this kind are written with the object of presenting the claims of some particular lamp or system of illumination. It is also only reasonable that manufacturers should seek to interest the general public in their wares, since it is on the general public, after all, that the commercial success of lighting apparatus largely depends. But we think that in such cases a clear distinction ought to be drawn between purely advertising matter, information preliminary to the issue of a prospectus, and the like, and genuine articles written for the benefit of the readers of a paper.

During the last few weeks there has been a flood of literature of this kind. In popular articles of this variety one must not expect a pedantic accuracy of statement, but we feel bound to say that much of what has been written has overstepped the permissable margin of exaggeration. The over-coloured statements as to the respective merits of gas or electric lighting, and especially the belittling, by representatives of one system of illumination, of the merits of other methods, leads to a great deal of unnecessary bitterness, and, moreover, does not achieve its object. The public is becoming weary of these obviously bewildering and contradictory statements. On one morning the reader is met with the triumphant declaration "Gas superseded by Electricity." In the next breath he is informed that "Gas at the worst is better than electricity at the

best." He not unnaturally draws the conclusion that neither claim is above suspicion and the only ultimate effect is to produce a feeling of scepticism and distrust.

All this helps to retard the education of the public to appreciate what constitutes good lighting, and serves to destroy the interest in matters of illumination which has recently been made manifest.

One unfortunate consequence of the indiscriminate publication of literature of this description is that each fresh effort provokes reprisals in the same strain. We believe that it does little good to either interest, and prefer to accept the view of Mr. R. R. Young, who pointed out in a paper before the National Commercial Gas Association (U.S.A.) that any marked advance in either system of illumination benefits the other, because it helps to bring about a higher standard of illumination. How much better, therefore, it would be to point out the directions in which an illuminant really can be utilized with effect, instead of insisting on its superiority under all imaginable conditions, and to encourage a more liberal use of illumination instead of always harping on the question of cost.

If those connected with different systems of illumination could only come to an agreement to abandon this mutually destructive warfare, and instead to insist upon the value of good illumination without attacking and exposing each other, all systems of lighting would benefit.

Pyrophoric Ignition Devices.

It is very interesting to observe how many modern inventions are simply modifications of the crude efforts of the distant past. We see, again and again, discoveries made and patents taken out, only to be subsequently forgotten and replaced by other and, at the time, better methods of achieving the same end. Subsequently new facts are discovered and the march of chemical and physical science leads the investigator of the present day into the very lines of experiment which had been attempted and ultimately abandoned in the past.

For example, the development of the metallic filament glowlamp leads us to recall that the very earliest experiments on incandescent filaments were made with metals. Edison and Swan both covered this field of research exhaustively, but it was only when they hit upon the carbonized filament that their efforts were crowned with enduring success. For over twenty years no radical departure was made from their methods, and it is only quite recently that later discoveries have paved the way for a reversion to metallic filaments once more.

The recent development in pyphoric ignition, which is discussed by Dr. Böhm in an interesting article in the present number, is another illustration of the same tendency. The very earliest methods of producing fire, depended upon rubbing of two surfaces together. Among primitive peoples of to-day fire is still kindled by friction between two pieces of wood—and a very arduous process it is said to be. Gradually a change came about. The old tinder box with its uncertain percussion of steel and flint, was completely superseded by the chemical ignition of the phosphorous match, gradually developed to the perfection of to-day. But the rubbing methods of producing fire have once more come to the fore owing to the discovery of the properties of the mineral cerite which produces much larger sparks, and with much greater certainty, than the old tinder box could do. It is early as yet to attempt to forecast the part to be played by pyphoric methods in the future. It appears, however, that a considerable advance has already been made on the Continent, and considerable claims are made on behalf of the convenience, cleanliness, and safety of this method of ignition.

It has been stated that many fires are caused annually by the careless throwing down of incompletely extinguished matches upon inflammable material, and through their being played with by children.

The matter is naturally of special interest to the gas industry. Persistent attempts are being made to devise simple and reliable methods of automatic ignition so as to give gas-lighting some measure of the advantages enjoyed by electricity in this respect. In certain directions, notably in connexion with the automatic control of street lamps, considerable progress has already been made, and we look for yet further developments in the future.

The Association of Consulting Engineers.

Attention is drawn elsewhere in this number to the formation of an Association of Consulting Engineers. We sympathise with the feeling that the title of "Consulting Engineer" should carry with it more definite qualifications. Seeing that at present anyone is free to describe himself in this way, it seems desirable that the public should be protected by some guarantee as to the competence and trustworthyness of the consulting engineer they employ, and the intentions of the Association in this direction deserve consideration.

Another respect in which there seems a need for some organization is in the gaining of a more precise code of professional etiquette. The consulting engineer is often placed in a very delicate position where a knowledge of the recognised and usual custom is essential. The older engineers—the men of established reputations—whose advice is habitually sought in connection with big undertakings, have acquired this knowledge through years of experience. But the younger engineers, with little experience behind them, are often at a loss, and an Association which could lay down the present ruling on these matters with authority might do useful work.

It must of course be recognized that there are many varieties of consulting engineers, and this alone renders the problem of stating precise rules and regulations a somewhat difficult matter. In addition the contemplated Association, being a self-appointed body, can only gradually acquire the right to speak with authority. There will be need for considerable care in drafting its constitution and in selecting its present line of policy, if it is to command the full confidence of the public.

There is one direction, however, in which an obvious opportunity for good lies before the Association, namely in bringing together consulting experts in many different branches. We have always felt that the sharp distinction which is apt to be drawn between the gas and the electrical engineer was regrettable, and we are glad to see that the nominated Committee contains representatives of the gas, electrical, civil, and allied engineering professions.

The Lighting of Museums and Public Buildings.

In our last issue an Engineering Correspondent, who was responsible for the critical description of the lighting in the New South Kensington Museum in the May number of *The Illuminating Engineer*, added some comments on the adjacent Old South Kensington Museum. It is not altogether surprising to find that in this building the conditions of illumination are considered distinctly inferior to those in the new building, though, even in the latter case, it was pointed out that there was room for considerable improvement. To collect together priceless carvings, vases, and other works of art, and then to provide such a feeble order of illumination that their appearance is blurred by obscurity, seems rather inconsistent.

It might be suggested that at the present time, when the value of good

illumination is so fully appreciated, and when new illuminants and methods of distributing light, unknown at the time this installation was erected, are available, an improvement in the old conditions might well be taken in hand.

Even at present it must be admitted that important public buildings are still being put up, and systems of lighting installed in them, in which full advantage is not taken of the latest developments in lamps, fixtures, or shades. We are aware of a number of buildings in which this neglect is leading to a continuous waste of energy which can easily be remedied. It should often be possible, by re-arranging the lights, to provide infinitely better lighting conditions than at present, and yet to make a considerable saving.

The above remarks hold good for many large offices. In the case of buildings of special national importance, such as Museums, they apply with special force. In such cases it is not enough merely to arrange the lights so as not to violate the fundamental rules of good illumination. In addition the character of each room, and the nature of the exhibits it contains, ought to be carefully borne in mind. Presumably the arrangement of the lighting might be so contrived as to stimulate interest and to throw a glamour over the surroundings instead of being toneless and inefficient. We have sometimes heard it remarked that the upkeep of all these national treasures is but ill repaid by the small number of people who visit the Museums to study them. But the question also occurs to us whether this may not be largely due to the fact that they are so often exhibited under uncongenial conditions. The dim illumination and murky obscurity of certain portions of the South Kensington Museums are hardly such as to arouse curiosity. On the contrary, the subdued gloom is probably often responsible for the visitor immediately turning his steps elsewhere.

It may, of course, be said that these remarks are founded on personal impression, and in this connexion we should like to see a series of measurements of illumination made in many of these buildings in order to see how far personal impression is in accord with the actual facts. Curiously enough, the contribution by Mr. A. P. Trotter in the last number referred to a series of measurements of the illumination in the South Kensington Museums in 1892. A repetition of some of these tests would seem to be timely, in order to ascertain how far, if at all, conditions have been improved during the years which have elapsed since that date.

In this connexion we should like to refer once again to the admirable precedent set by the Home Office in the recently issued Report of H.M. Chief Inspector of Factories, an abstract of which we are publishing in the present number (p. 493).

Authorities are now fully conscious of the importance of good illumination in factories. But why should the matter rest here? Surely the lighting of many public buildings, and of rooms in which large numbers of Government employees are at work, is at least equally important? The lighting of the museums, and many other buildings of national importance, admittedly defective in many cases, deserves the attention of the Office of Works. It is also to be hoped that the conditions of illumination in many post offices and telephone exchanges will be materially improved, and we commend this matter to the notice of the Postmaster General.

We trust that the lead given by the Home Office in this respect will be followed by other departments, and that the importance of good illumination will be more fully appreciated in the future than in the past.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter continues his notes on the ILLUMINATION OF VARIOUS STREETS AND INTERIORS (p. 479). In the present instalment he gives the results of tests on various streets in the City of London in 1892, illustrating his remarks by a number of curves showing the distribution of illumination in each case.

Following this (p. 484) there is a note on a recent meeting held for the purpose of forming an "ASSOCIATION OF CONSULTING ENGINEERS." It is pointed out that some such organization is desirable, both as a means of improving the status of the consulting engineer and also for the benefit of the general public. At present, it is contended, there is no adequate safeguard that the man whose advice as a consulting engineer is sought will be a thoroughly competent and experienced member of the profession.

Prof. F. K. Richtmyer (p. 485) deals with EDUCATION IN ILLUMINATING ENGINEERING. He discusses the possibility of arranging for a special course on this subject in the college curriculum and of dealing adequately with all the different phases of the subject. He then proceeds to give some particulars of the work of students at Cornell University, including a summary of some tests on the Weber Illumination photometer. In the continuation of this article details of tests of distribution of illumination with the instrument will be given.

Dr. E. P. Hyde concludes his article on THE RADIATION OF METALS (p. 488). He discusses the application of the several radiation formulæ to the behaviour of such metals as platinum, tungsten, and tantalum and points out that the Wien relation is not rigidly applicable owing to the fact that the so-called constant "α" in this formula varies at different parts of the spectrum.

A paper by **Dr. H. E. Ives** and **Dr. W. W. Coblentz** (496) deals with the RADIATION OF THE FIREFLY. The efficiency of the distribution of energy in the spectrum of this source of light is pointed out and the suggestion is put forward that, by analysing the phosphorescent constituents that occur in the bodies of certain insects, we may eventually learn how to produce a practicable light source on this basis.

On p. 493 will be found a summary of the portions of the recently issued REPORT OF H.M. INSPECTOR OF FACTORIES dealing with illumination. It is pointed out that justice has not been done to this important subject in the legislation of the past. The Home Office are fully conscious of the necessity for good lighting conditions in factories and workshops and instances are given by several inspectors of cases in which lack of care in this respect has had a prejudicial effect on the health and eyesight of employees. The question is now being carefully considered. A series of measurements of the illumination in underground basement premises is now being carried out, and particulars are given of the results obtained in a number of interiors of this description. Before making definite recommendations on the subject, however, much patient study and collection of data bearing on the matter is essential.

Dr. C. R. Böhm (p. 503) deals with PYPHORIC IGNITION DEVICES. He remarks on the tendency of inventors to return to the old grooves and to re-examine processes which had pre-

viously been abandoned in favour of some apparently preferable method. For example the pyphoric kindling apparatus, utilising the metal cerite, is merely a modification, with improved materials, of the old tinder box in which a light was obtained by striking steel and flint together. Considerable progress in the manufacture of apparatus of this kind has recently been made on the Continent. At present there appear to be two chief varieties of igniting devices, those intended for kindling gas flames and those designed for use to replace pocket match boxes, &c. The author also enters into the history of the patents bearing on the subject pointing out the great advantage the industry has enjoyed owing to the free competition.

An Engineering Correspondent (p. 506) concludes his article describing Tests on Incandescent Mantles, Glow lamps and Arc lamps. In the present instalment he gives some particulars of the life of metallic filament glowlamps and then proceeds to describe a rotating lamp holder for use in tests of electric glow lamps and an arrangement enabling the polar curve of light distribution from arc lamps to be readily obtained.

Mention may next be made of the article on Indirect Illumination on p. 505. This contains a discussion of the merits of this style of lighting and of the various defects which must be avoided. Some illustrations are given of lighting installations of this kind in the United States, where the method is said to be making considerable headway.

A paper recently delivered by **Prof. G. S. Barrows** at the Third Annual Convention of the Illuminating Engineering Society in the United States on The Work of Welsbach is also abstracted elsewhere in this number (p. 499). This contains an account of Welsbach's early researches on the incandescent mantle, on metallic filament lamps, and on pyphoric materials, &c.

Developments in incandescent mantles are also dealt with in a short note on p. 492. This refers to the recent researches of M. Greyson de Schodt which were summarized in a paper before the Société Technique du Gaz. He describes a method of using incandescent mantles in an inclined position, backed by a metallic reflector. By this means the natural polar curve of light distribution is improved and there is claimed to be a considerable gain in the officiency of street illumination, the amount of light directed on the pavement being substantially increased. Clusters of three or more such mantles are also used. An interesting feature is that the angle of inclination of the mantles can be varied to suit the local conditions.

Among other articles in this number reference may be made to an account of the method of Illuminating the External Architectural Features of a Building at the Brusselles Exhibition (p. 490). This consists in directing the light on to the walls themselves instead of following the outline of the building in naked glowlamps. Additional miniature lamps are used to outline the roof.

Another note calls attention to the importance of the Proper Lighting of Art Schools, and some notes are given of a case in which the lighting was several times modified (p. 504).

At the end of this number will also be found reviews of a series of recently issued works dealing with Illuminating Engineering, Tables for Illuminating Engineers, Colour Vision, The Incandescent Mantle, &c.

On p. 525 there is the usual Review of the Technical Press.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

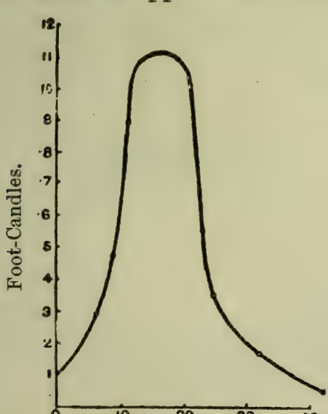
Illumination, its Distribution and Measurement.

By A. P. Trotter.

Electrical Adviser to the Board of Trade.

(*Continued from p. 425, Vol. III.*)

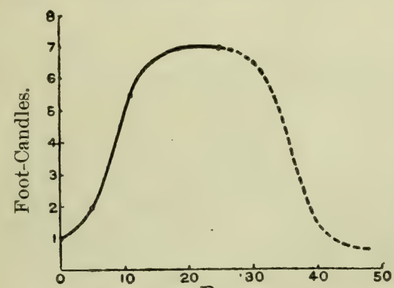
City of London.—The street lighting in the City was measured by me on several occasions. A very large number of repeated observations would be necessary to give an exact result, since there was a considerable variation of light when the arc-lamps "fed." The three curves A, B, and C (Fig. 125), were picked from a number, as the best performances of the lamps. In these curves all the readings in any one set of observations are recorded; none have been suppressed as doubtful.



A

Fig. 125. Feet

The curves are drawn to represent the probable distribution of illumination as nearly as possible. The horizontal distances are given in feet, and the scale of foot-candles has no relation to the height of the lamp, as in the first section of these articles. In several of the highest cases it was noticed that the light was not thrown uniformly, owing to the formation of the crater

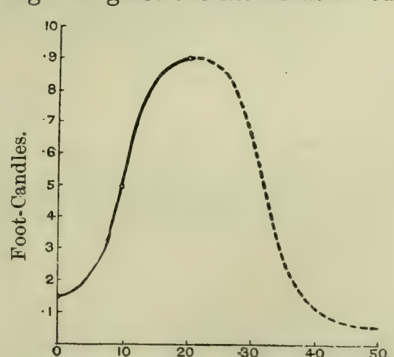


B

Fig. 125.

on one side, perhaps on account of bad setting of the carbons.

Fig. 126 gives the illumination curve



C

Fig. 125. Feet

of a lamp in Cornhill, measured along the diagonal line of the direction of another lamp. A considerable crowd

had collected when seven readings had been taken, and it is assumed that the remainder of the curve would be symmetrical, as shown. Fig. 127 is the curve C (Fig. 125A) on another scale. The maximum light being given at about 45°, and $\cos^4 45°$ being 0·25, the value of the illumination at the maximum is to be found on the scale of foot-candles, at a height equal to 0·25 of the height of the lamp, this height being measured in feet on the same scale as that of the horizontal distance.

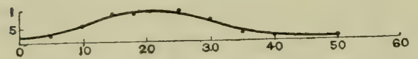


FIG. 127.

On a visit on May 6th, 1910, with the object of repeating some of these measurements, I found that gas had replaced electric light in Queen Victoria Street. On the position occupied by lamp B, Fig. 30, a double mantle gas lamp gave a maximum of 0·34 foot-candle, less than half of the illumination on the same spot eighteen years before.

In the course of a very careful measurement of the lighting in Queen Victoria Street, on the 29th of January, 1892, it happened that the light of the three lamps was, during the greater part of the test, below the average. A plan of the portion of the street, corrected from the ordnance map, is given in Fig. 128. The three lamps are marked A, B, C, and a line across the street at the minimum is marked D E. The illumination curves in Figs. 129 and 130 show the actual

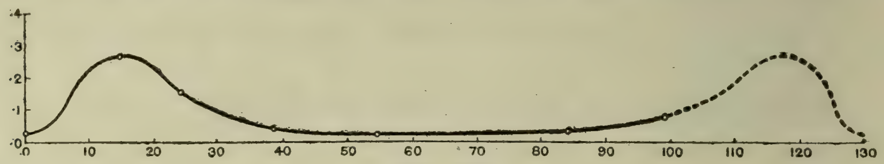


FIG. 126.

readings. Starting from A, the illumination was 0·1 foot-candle at the foot of the lamp-post. A few seconds later, at a distance of 11 ft., before another reading could be taken, the lamp fed, and the reading at this point was the same. The measurements were continued without interruption, and the early ones probably represent the lowest illumination that was to be found under these circumstances. On approaching B the light was good, and was a fair average of what I had found in some dozen or more tests. On starting towards C, lamp B fed, and C appears to have been below the average of this series of measurements. The measurements

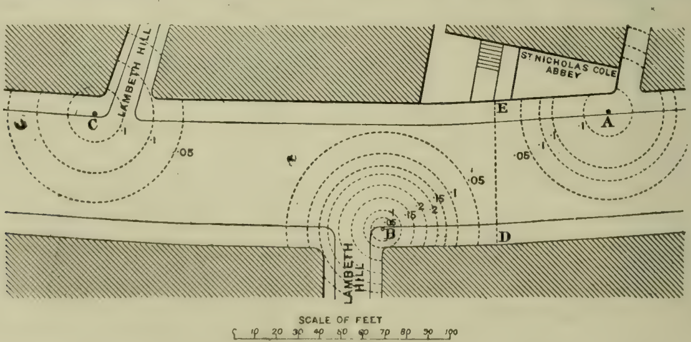


FIG. 128.

of distance were made with a tape; the assistance of the police constables, kindly provided by Inspector Fraser greatly facilitated the work, by diverting the traffic and by keeping off bystanders. The contour lines are practically circles. It has been

assumed, in the circles drawn in Fig. 128, that lamp C was burning well. If the contour of 0·04 foot-candle had been drawn, it would probably have been of the hour-glass kind*, just looping

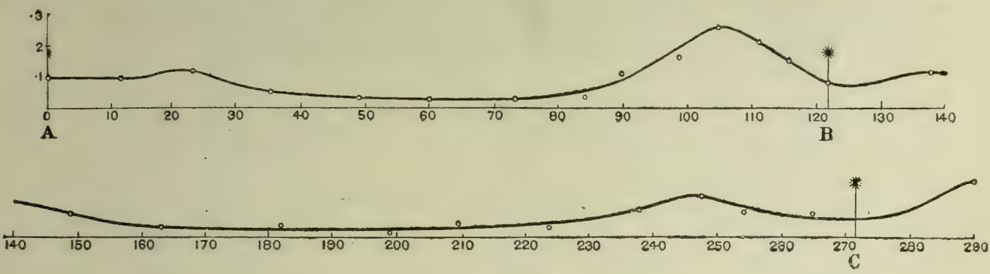


FIG. 129.

on to the pavement near the minimum. The arc-lamps appeared to about 17 ft. 8 in. high, and the distance of the lamps apart was about 6·5 times their

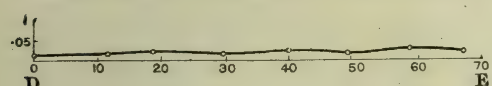


FIG. 130.

height. These have now been replaced by gas lamps.

On May 6, 1910, the illumination at the point E, Fig. 128, by gas lamps,

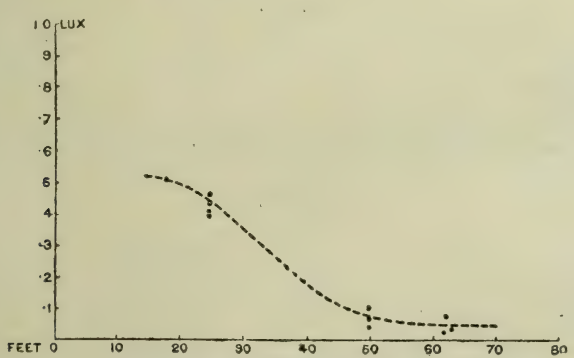


FIG. 131.

was 0·012 foot-candle and the maximum near the lamp at A was 0·38.

A number of measurements, made under the direction of Sir W. H. Preece, with his photometer, on different dates, and in different parts of Queen Victoria Street, are represented in Fig. 131, and an attempt has been made to draw a curve among them. The ordinates are given as decimals of a lux (Hefner-metre).

Whitehall.—On February 11th, 1892, a careful survey of Whitehall was made. Fig. 132 is a plan of the part of the street between Downing Street and Whitehall Gardens. The gas lamps are marked A to N, both on the plan and on Figs. 133, 134, 135, and 136, which give the illumination curves along the measured lines. Only a single reading near the minimum has been suppressed, being obviously wrong. I was informed by Messrs. Sugg & Co. that the lamps were of the following description:—The small side lamps were 'Whitehall' pattern, and were of 90 candle-power, consuming 20 cubic feet per hour. The large lamps were of the 'Westminster' pattern, of 270 candle-power, consuming 50 cubic feet per hour.

The illumination curves show very clearly the effect of the shadow below

* Vol. I, p. 360.

the ordinary lamps. The large lamps at the "refuges" were provided with reflectors, which greatly lessened the shadow. Either because the transverse line A Q was not taken immediately below the lamps B and C, or by some error in the measurements, the shadow below these lamps does not appear plainly. From these illumination-curves may be seen the gradual rise of the minimum between A and D and between F and G, owing to the effect of the lamps at the refuges. The moon was nearly full, and the sky was cloudless.* The dotted line represents the illumina-

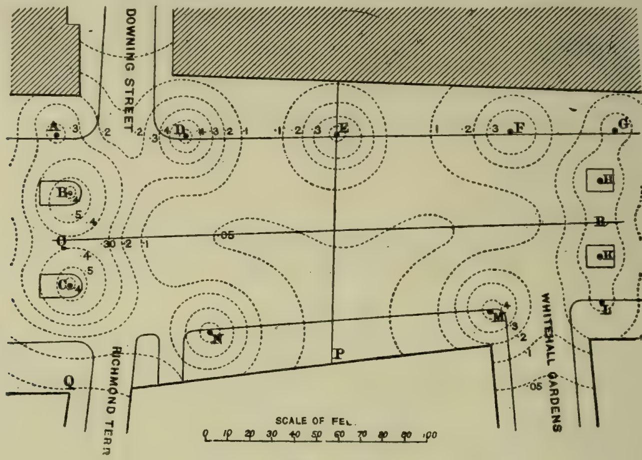


FIG. 132.

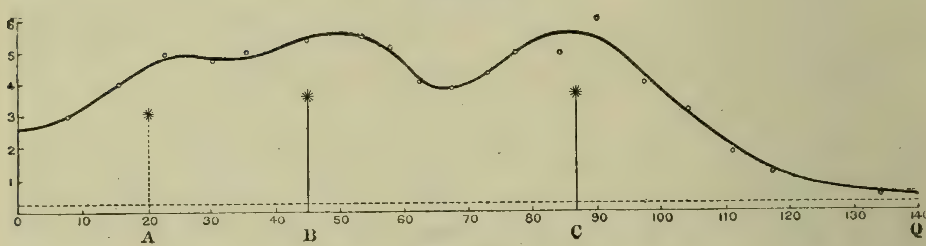


FIG. 133.

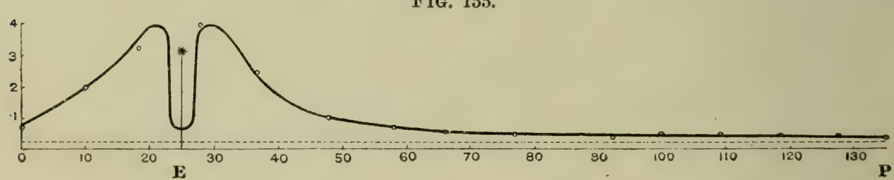


FIG. 134.

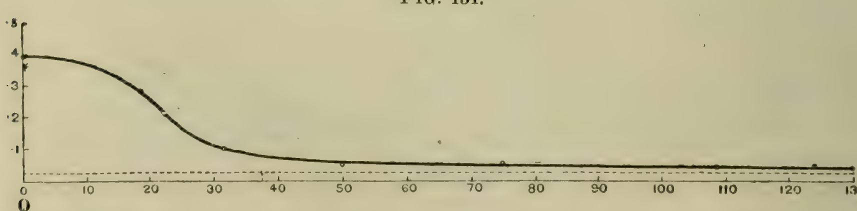


FIG. 135.

* Several attempts were made to measure street illumination on moonlight nights when clouds were drifting over the sky. Although attempts were made to screen the photometer from the moon, the measurements were very irregular.

tion, 0·025, due to moonlight. The survey was completed at about 11 p.m. From these curves the contour-lines in Fig. 132 were drawn, and from these contour-lines I constructed a model on the scale of 20 ft. to an inch in plan, and 1 foot-candle to an inch in elevation.

expected that I repeated the measurements of the maxima and minima at Whitehall on February 25th, and proceeded at once to Queen Victoria Street, where I made twelve measurements of maxima and minima. I then returned to Whitehall and repeated the observa-

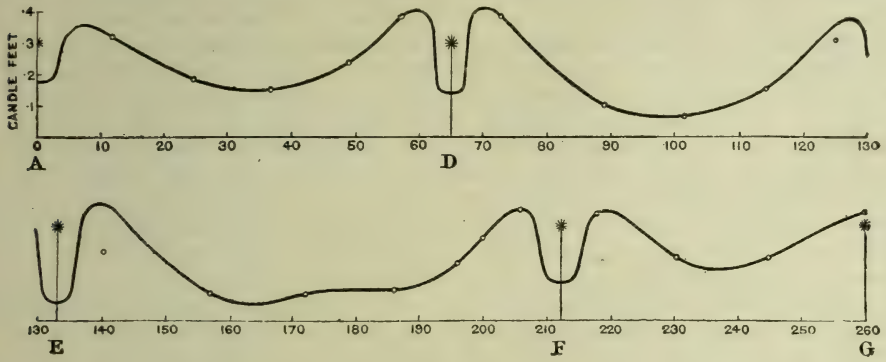


FIG. 136.

Fig. 137 gives some measurements which I made on April 22nd, 1910, between the points E and G, Fig. 132. The lamps have been re-arranged. The upper curve was taken with the photometer some 4 ft. from the ground, the

tions, thus ensuring that no error could be caused by variation in the power of the electric lamp in the photometer. The measurements were in accordance with the results which have been given. An attempt to read a Bellows' French

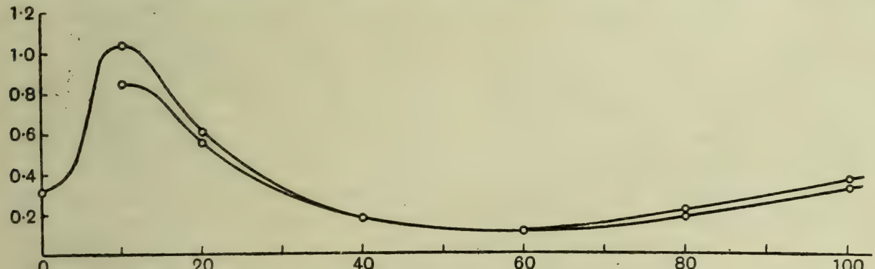


FIG. 137.

lower with the screen $7\frac{1}{2}$ ins. from the ground. The maximum illumination was about twice the maximum in 1892.

The difference between the illumination in Queen Victoria Street and in Whitehall was so very much less than I

Dictionary at different parts of the street seemed to show that the light in Queen Victoria Street was rather more useful, but the lighting in Whitehall was certainly less dazzling.

(To be continued.)

Institution of Municipal Engineers

(SOUTH EASTERN SECTION).

CHAIRMAN FOR NEXT SESSION.

The Members of the South Eastern District of the Institution of Municipal Engineers have elected Mr. Henry C. Adams, Consulting Municipal Engineer, as their Chairman for the second year in succession.

Association of Consulting Engineers.

A MEETING, presided over by Sir William Preece, K.C.B., F.R.S., the past President of the Institution of Civil Engineers, was held this week to consider the desirability of forming an association of Consulting Engineers, the object of the association being (*a*) to form a recognized group of *bona fide* independent consultants who would constitute a body for the protection of their interests and the interests of the public generally; (*b*) to improve their status and professional position, following the examples of the Council of the Bar, of the Medical Council, and of the Chartered Accountants.

The object of the meeting was to see whether the general idea of the formation of the association met with the approval of the consulting engineers in this country. Mr. Midgley Taylor, who presided, in the absence of Sir William Preece, at the beginning of the meeting, pointed out that it was necessary, in the interests of the public as well as in their own, that the genuine consulting engineer should be distinguishable from those who were not genuine consulting engineers, but had trade interests. At the present time, if a municipal authority erected works, even of large magnitude, they were not compelled to employ a qualified man to advise them, and there was nothing to prevent an absolutely unqualified man going to the particular authority, offering his services, and being retained. It was an anomaly for this to be possible in matters where public safety and the expenditure of large sums of public money were involved. In matters of health, or law, or finance, the safeguard was that the doctor, or solicitor, or accountant who was consulted was a member of a recognized body, and it was felt that the public should have the same protection in engineering matters.

Mr. Swinburne formally proposed the creation of the Association, and asked the meeting to look at the matter as broadly as possible, and all work together for the one end.

After some discussion, Sir William Preece, as Chairman, said that he was in entire sympathy with the movement. He put the resolution to the meeting that the Association be formed, and this was carried unanimously. It was then suggested that the following gentlemen should be asked for form a Committee: Messrs. Robert Hammond, C. Hunt, B. M. Jenkin, Baldwin Latham, S. R. Lowcock, E. L. Mansergh, W. M. Mordey, W. H. Patchell, Sir Wm. Preece, Henry Rofe, J. F. C. Snell, E. H. Stevenson, James Swinburne, Midgley Taylor, Henry Woodall.

This Committee was unanimously elected, and Mr. A. H. Dykes, of 1, Victoria Street, Westminster, London, S.W., was elected as honorary secretary.

Lectures on Law Relating to Engineering.

WE understand that the Councils of the Junior Institution of Engineers, and the Society of Engineers, have arranged for a course of six fortnightly Lectures on "The Law relating to Engineering" to be delivered by Mr. L. W. J. Costello, M.A. LL.B., commencing October 10th.

Junior Institution of Engineers.

NEW PRESIDENT.

SIR J. J. THOMSON, F.R.S., Cavendish Professor of Experimental Physics of the University of Cambridge, has been elected President of the Junior Institution of Engineers in succession to Sir Henry J. Oram, K.C.B., Engineer-in-Chief of the Fleet.

Instruction in Illuminating Engineering.

By F. K. Richtmyer (Professor at Cornell University, Ithaca, U.S.A.)

The writer has been much interested in the recent discussions in the pages of this journal regarding the introduction into our technical schools and colleges of instruction in illuminating engineering. While there is much to be said on both sides of the question, the ultimate decision must be based on the results of experience. If we assume, as do many writers and some educators connected with engineering schools, that engineering education should lie strictly along general lines, and that all specialization and professional training should be "picked up" after the student has graduated and is in touch with the various professional problems to be attacked, we at once dismiss the possibility of education in illuminating engineering, as such.

If, on the contrary, we advocate the graduation, on a more or less general foundation, of students, with a degree in "Illuminating Engineering," ready to solve, by means of their college training, any and all problems that may arise, we must lay out a course of training so broad and so comprehensive that a considerable time would be required for its completion. For the illuminating engineer must not only be trained along lines of illuminating engineering, but he must be an electrical engineer, a mechanical engineer, a chemist of no mean ability, and, in addition, he must have a sense of artistic proportion of a highly spcialized type. It would be hardly possible, in a college course of the usual length, even to touch on all these things.

As is frequently the case with two radically different views, the correct one lies somewhere in between, embodying parts of both. So it seems here. Illuminating engineering has become commercially too important to pass entirely unnoticed by our general engineering schools, and yet the fundamental principles of engineering education, as interpreted by our better universities, are opposed to too great specialization.

Perhaps a satisfactory arrangement would be that at present used in several universities, namely, to distin guish between mechanical, electrical, hydraulic, and marine engineering, &c. The instruction in these courses is identical during the first three years. In the fourth or senior year, students of the various branches diverge, each class taking those subjects applying to its particular department. The obvious result is that the embryo engineer at graduation has been given a general training, sufficient to make him an "all around" man, and in addition he has received sufficient specialized instruction so that he is at least familiar with the type of problems appearing in his own line, and knows in a general way the methods employed in their solution. This course, followed by two or three years as apprentice to some reliable engineering company, seems to have proven rather popular, and while, as applied to illuminating engineering, such an arrangement leaves much to be desired, it is probably the best compromise under existing conditions.

Although such an arrangement as suggested above has not been contemplated at this university, nevertheless it might be interesting to record what is being done in this direction. A two-hour-per-week lecture course (for one term), given by Prof. E. L. Nichols of the department of physics, deals with the subjects of photometry and the physics of illumination from the historical and the theoretical standpoint. Accompanying this is a laboratory course, dealing with photometry and illuminometry, given by the writer in collaboration with Prof.

Ernest Blaker. A third course, given by Prof. G. S. Macomber, of the department of electrical engineering, discusses the commercial practice and applied theoretical aspects of illuminating engineering.

The outline of the laboratory course has already been given,* and while it contains no material essentially new, the character of the work done by the students may be of value in the discussion of the general subject of instruction in illuminating engineering, for it is hardly necessary to say that the photometer and its use are as important to the illuminating engineer as the ammeter and voltmeter and laboratory work in electricity are to the electrical engineer.

In working out the details of this laboratory course in photometry and illumination, we have tried to keep constantly before the student the fact that in practice we are concerned fundamentally not with the candle-power of a light source, but with intensity of illumination which the source is capable of producing; that it is only a matter of operative convenience that our fundamental photometrical quantity is a candle-power unit rather than a unit of intensity of illumination.

To illustrate the emphasis placed on the idea of intensity of illumination the method of calibrating and using the Weber photometer may be cited. As defined in our laboratory, the fundamental constant of this instrument is "the intensity of illumination on the front surface of the test plate necessary to cause a setting of the comparison screen at 10cm. (or 100 mm.)." This constant is called I_{10}. Assuming the photometer tube to obey the inverse square law, it is readily seen how this I_{10} may be determined by placing a source of known candle-power at a measured distance in front of the test plate, producing a known intensity if illumination I_s, correspond- to a setting of the comparison screen at r_s. I_{10} may be found from

$$\frac{I_{10}}{I_s}=\frac{r_s^2}{10^2} \quad \ldots \quad (1)$$

* *Illum. Eng.*, vol. II., p. 851 (Dec., 1909).

Conversely, knowing I_{10}, any unknown illumination may be found from

$$\frac{I_{10}}{I_x}=\frac{r_x^2}{10^2} \quad \ldots \quad (2)$$

or

$$I_x=\frac{I_{10}}{r_x^2}\cdot 10^2 \quad \ldots \quad (3)$$

where I_x and r_x represent the unknown illumination and the corresponding photometer setting respectively. And if one is measuring candle-power:

$$C_x=\frac{I_x}{D_x^2} \quad \ldots \quad (4)$$

where D_x represents the distance between the test plate of the photometer and the light source C_x. Note that the quantities, *i.e.* I_x, computed *directly* from the photometer observations, are intensities of illuminations.

Again suppose we wish to determine whether the scale of the photometer is correctly located with respect to the comparison source, and also whether the photometer obeys the inverse square law. Assuming r_o to be the distance (positive or negative) between the zero of the scale and the comparison source in the Weber, we might write equation (1):

$$\frac{I_{10}}{I_s}=\frac{(r_s+r_o)^2}{10^2} \quad \ldots \quad (5)$$

or

$$\frac{1}{\sqrt{I_s}}=\frac{1}{10\sqrt{I_{10}}}\cdot(r_s+r_o) \quad \ldots \quad (6)$$

A simple mathematical analysis of this last equation would show that if we produce a series of illuminations I_s on the test plate by placing a lamp of known candle-power at different measured distances in front of the test plate and obtain in each case the corresponding photometer reading r_s, then a curve plotted in rectangular co-ordinates between $1/\sqrt{I_s}$ and r_s ought to be a straight line. If it is not a straight line the tube does not obey the inverse square law, and suitable corrections can be readily made. If the curve does not pass through the intersection of the co-ordinate axes, the scale is incorrectly located and the "off-set," or r_o, can be read directly from the curve. Fig. 1 is an actual

curve plotted from data obtained by two students taking the course. The curve is approximately straight, showing that the photometer tube very nearly obeys the inverse square law,

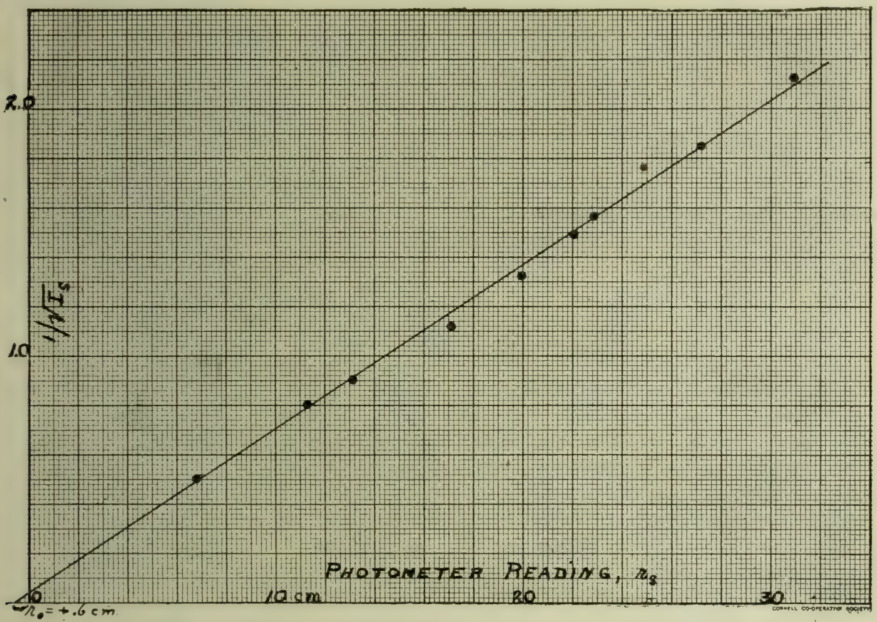


FIG. 1.—Calibration Curve of Weber Illumination Photometer.

but that the miniature incandescent lamp used was mounted approximately 0.6 cm. beyond the zero of the scale, for which due correction must be made in using the photometer.

After doing the above work on the Weber the student cannot but realize that the quantity measured directly by the photometer is intensity of illumination, and that to measure *candle-power* a second measurement must be made, *i.e.*, the distance between the light source and the test plate of the photometer.

(*To be continued*).

Variable Illumination.

A NEW customer may accept as satisfactory the assurance that the live voltage of an electric supply company will not vary more than 5 per cent from the normal. It is hardly reasonable to suppose that he would accept with the same complacency the equivalent statement that his lamps would fluctuate from 12 to 20 candle-power or that the illumination of the page as he sat before his reading lamp would vary from 1·5 to 2·5 foot-candles.—L. B. Spinney, *Elec. Review*, N.Y., June 4.

Meter Reading Lamps.

THOSE who are constantly required to read meters, both gas and electric, will doubtless have been struck by the fact that they are frequently placed in some inconvenient dark corner, and a glimpse of the scale can only be secured by striking matches. *The Progressive Age* refers to a convenience utilized by meter inspectors in the United States, namely, a portable storage cell supplying current to a 2-candle-power small lamp. The arrangement can be conveniently carried in the coat pocket.

On the Radiation from Metals.

By Edward P. Hyde.

(Abstract of a paper presented before the American Physical Society, Washington, April 22, 1910.)

(*Concluded from p.* 450.)

In connexion with a mathematical investigation of the various laws of radiation a very interesting deduction from the Wien Law of spectral energy distribution was made and tested experimentally. The generalized form of the Wien equation may be written as follows :

$$J = C_1 \lambda^{-\alpha} \Sigma^{\frac{-C_2}{\lambda T}}$$

in which λ = wave-length, T = absolute temperature in degress centigrade, and C_1 C_2 and α are constants. For a "black body" α 5. It has frequently been assumed that this equation, with different values of the constants, may be taken to represent the radiation from platinum and other metals.

If we assume that this equation with different constants may be employed to represent the distribution[8] of energy in the visible spectrum of the various metals, it is easy to show that if two filaments are at a colour match at low temperature, and are brought again to a colour match at higher temperatures, the ratios of the candle-powers of the two filaments must always be the same over whatever range of temperature the comparisons are made. This conclusion results only if the constant "α" remains constant over the range of temperatures. If instead of the Wien equation we substitute that of Planck which is more rigorous for a "black body" the same deduction follows for all ordinary temperatures, since the measurements are confined to the short wave-lengths of the visible spectrum.

This conclusion seemed to be verified quite closely by the data which had previously been obtained with another end in view, The experiment was carried out anew, however, with all three of the metals, tantalum, tungsten and osmium, using carbon as a comparison source. For the first two metals mentioned the relation between colour and intensity as compared with carbon, persisted accurately over a large range of temperature ; for osmium some slight deviation was observed, such that if carbon and osmiam were brought to a colour match[9] (*i.e.*, as close as possible) at low temperature, and then again to a colour match at a somewhat higher temperature, the ratios of the candle-powers of the two filaments were not quite the same at the two temperatures.

Since the above observed relation was deduced on the assumption of the Wien (or Planck) equation with "α" constant, the results of the experiment indicate that if the distribution of energy in the visible spectrum is represented at any temperature by the Wien (or Planck) equation, it is represented by the same equation with the same value of "α" for all temperatures over a relatively wide range for tantalum and tungsten. The deviations found for osmium are such as would result from a very small change in "α" with temperature.

The conclusion that if the Wien or Planck equation (in its general form) is assumed to represent the distribution of energy in the visible spectrum of the metals studied at any temperature, then "α" must remain constant or very nearly so over a moderately

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8 The exact assumption is not that the Wien equation represents the distribution of energy in the visible spectrum, but rather than it gives the ratio of the energy emitted at two wave-lengths in the visible spectrum, taken for convenience as far apart as practicable (say λ=0·66, and λ=0 5 μ). The experiments described in subsequent paragraphs in terms of distribution in the visible spectrum, or of "integral colour" were in every case checked spectrophotometrically using two wave-lengths in the visible spectrum. But since the two methods agreed as to results the terms "integral colour" and "colour match" are used as short-hand expressions of the more exact conditions.

9 See note under 8.

large range of temperature, is in contradiction to the published results of other recent experiments[10]. The cause of the discrepancy is to be found, quite probably, in the fact that the Wien equation (which was assumed in the investigation to which reference is made) does not represent the distribution of energy accurately throughout the spectrum, so that "α" may be considered as a function of the wavelength rather than of the temperature. Whether or not the Planck equation[11] in its generalized form can be taken as representing the energy distribution in the spectra of metals is yet to be determined.

From a consideration of the published results showing "α" to vary with the temperature, it is immediately seen that the observed values of "α" lead to an inconsistency. Thus, if Wien's equation for spectral energy distribution is assumed, the Stefan-Boltzmann law for the total emission $E=\sigma T^{\alpha-1}$ must follow, since it is the integral of the Wien equation from $\lambda = 0$ to $\lambda = \infty$. But the observed values of "α," as for example in the place of platinum, decrease so rapidly with the temperature that if substituted in the Stefan-Boltzmann law they lead to the absurd conclusion that the total emission at 1,200° Abs. is about 2×10^6 times the total emission at the higher temperature 1,400 Abs.

It has been stated that if the Wien or Planck equation with "α" greater than 5 (the value for a "black body") represents the energy distribution in the spectra of metals, then "α" *must* decrease with increasing temperature, or else at sufficiently high temperatures the total emission of the metal would be higher than that of a "black body." The observed decreasing "α" was therefore thought to be in accordance with the requirements of the theory. But apart from the criticism that the observed changes in "α" are so great as to lead to the absurd conclusion that the total emission decreases with increasing temperatures, the theoretical conclusion that "α" must decrease needs some consideration.

As stated above, the Stefan - Boltzmann law follows as the direct integral of the generalized Wien equation. It also follows as a direct integral of the generalized Planck equation, but the value of the constant "σ" is different in the two cases. As deduced from the Wien equation

$$\sigma = C_1 T^1 (\alpha-1) \frac{1}{C_2^{\alpha-1}}$$

As deduced from the Planck equation, which is

$$J = C_1 \frac{\lambda^{-\alpha}}{\Sigma \frac{C_2}{\lambda T} - 1}$$

"σ" has the value

$$\sigma = C_1 T (\alpha-1) \frac{1}{C_2^{\alpha-1}} \sum_{\eta=1}^{\eta=\infty} \frac{1}{\eta^{\alpha-1}}$$

In either case "σ" is a function of "α" and so undergoes change with change in "α" As a matter of fact, at ordinary temperatures (up to 2,300 Abs.) and for ordinary values of "α" (up to $\alpha = 8$) a decrease of "α" produces not a decrease, but an actual increase in the total emission E. There is, therefore, no reason, from the consideration of the total emission, why at ordinary temperatures "α" should decrease with increasing temperature. Moreover, it is not clear to the author why the burden of responsibility has been placed upon the constant "α" rather than upon one of the other constants C_1, and C_2, both of which enter in the Stefan-Boltzmann law. It might be argued that a very small *increase* in C_2 with the temperature would prevent the total emission from rising too rapidly in cases where "α" is greater than 5. It may be significant in this connexion that changes in C_2 with the temperature would not affect the relation between colour and intensity which was employed to show that if the Wien or Planck equation represents the energy distribution in

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[10] Coblentz, Bureau of Standards Bulletin, vol. 5, No. 3, p. 329, 1909. Also *Elec. World*, vol. 52, p. 1345, 1908.

[11] *Phys. Rev.*, vol. 29, p. 553, 1909.

the spectra of metals at any temperature, the constant "α" must remain approximately constant at different temperatures.

From the data at hand the conclusion would seem to be that the Wien equation in its general form does not represent the distribution of energy in the spectra of metals, at least of the metals platinum, tantalum, tungsten and osmium. The variations in the observed values of "α" on the assumption of the Wien equation are due probably to variation with λ (which, of course, means that the equation does not represent the facts even at any one temperature) rather than to variation with the temperature, as has been suggested. But since the Wien equation is known not to represent the radiation even from a black body in the longer wave-lengths of the infra-red spectrum, it is not surprising that discrepancies should result when it is assumed to apply to the radiation from metals. It is a matter for further investigation as to whether or not the radiation from metals can be represented accurately by the generalized Planck equation, which in its specific form for a "black body" has a theoretical basis, and is verified approximately by experiment.

From the theoretical deduction, verified experimentally for tantalum and tungsten, regarding the relation between colour match and intensity match, it follows that if the generalized Planck equation is found to hold for metals at various temperatures, then "α" must be constant or quite closely so, independent of temperature over the range of ordinary temperatures. The so-called constant C_2 may or may not vary as far as the above considerations are concerned. Osmium shows peculiar behaviour which makes it an interesting subject for further study.

The Illumination of the Exteriors of Buildings.

When commenting upon the decorative illumination of the exteriors of buildings at the Franco-British Exhibition in 1908* attention was drawn to the fact that one plan was almost invariably adopted in using electric light for spectacular purposes, namely, to follow the outlines of the buildings in naked glow-lamps. It was pointed out that in the case of buildings having a white or good reflecting exterior, the method of illuminating the external architectural features, in preference to the exposure of large numbers of lamp-bulbs, was at least worth a trial. It may be added that this method has been followed in the United States by the illumination, for advertisement purposes, of the Singer tower by arc searchlights.†

Another illustration of this method is presented by the illumination, by the A.E.G., of one of the buildings at the Brussels Exhibition, as shown in the illustration on the opposite page. The exterior being white it was decided to illuminate the outside of the building by a series of concealed glow-lamps and 700 50 candle-power and 800 25 candle-power lamps were used for this purpose. In addition a portion of the building was outlined in glow-lamps, but it was recognized that it was unnecessary to use such big candle-powers here, and 2,000 fourteen volt 2 candle-power miniature lamps were employed. The contrast between the relatively dark roof and gables with the illuminated frontage of the house is said to be particularly striking. The whole represents a novel departure in spectacular lighting, and the general impression is said to be very "soft," and pleasing to the eye.

* *Ill. Eng.*, Lond., Vol. I., 1908, p. 665.

† *Ill. Eng.*, Lond., Vol. I., 1908, p. 739.

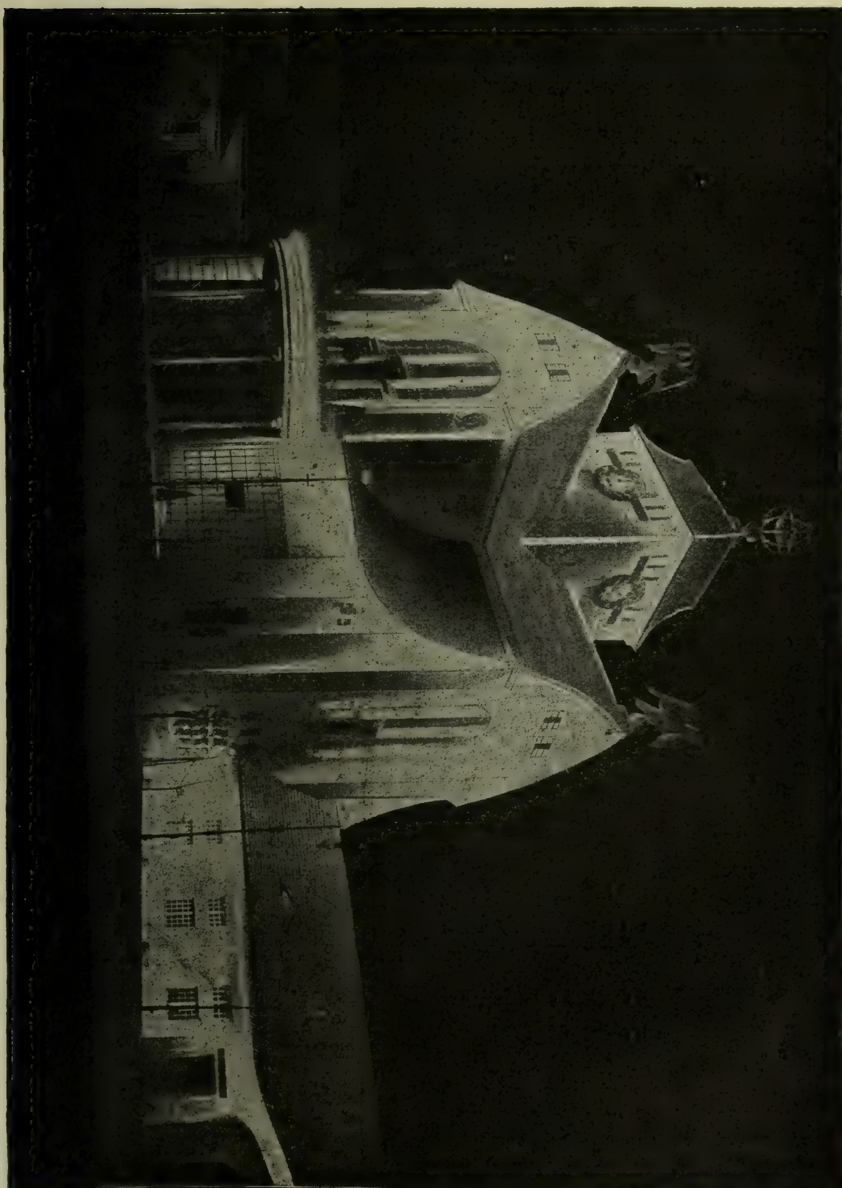


Fig. 1.—Illumination of the Exterior of a Building at the Brussells Exhibition by glowlamps, the light of which is directed on to the white walls.
By the courtesy of the Editor of the "A.E.G. Zeitschrift."

The Effect of Excessive P.D. on Tungsten and Carbon Lamps.

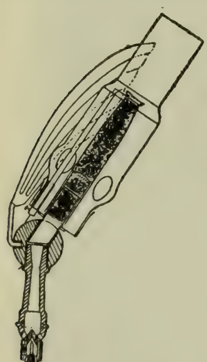
A recent paper by J. W. Howell before the American Institute of Electrical Engineers give some interesting data on carbon filament and tungsten lamps. He suggests that in general a metallic filament lamp will stand an excessive voltage better than a carbon one. Thus an increase of 3·7 per cent in the supply pressure will halve the life of a carbon lamp while it requires an increase of 5·2 per cent to have the same effect on a tungsten filament.

The Use of Inclined Incandescent Mantles.

(Based on a paper read by M. Greyson de Schodt before the Société Technique du Gaz.)

One advantage which has been claimed for the inverted mantle is the powerful downward intensity. The upright mantle, on the other hand, was less serviceable in this respect, for the parts of the burner necessarily obstruct, to some extent, the light immediately below the lamp.

An interesting development, described some time ago in this journal, was the horizontal "Tubus" burner, which was claimed to be specially serviceable for shop-lighting and for other purposes where it was specially desired to concentrate the light in a downward direction.* It will also be recalled that in the "Twinlight" device *both* an upright and an inverted burner were utilized, one below the other, with the object of securing increased efficiency and accentuating the downward illumination.†



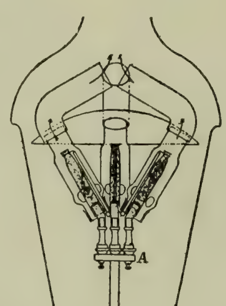


Fig. 1. Fig. 2.
Greyson Burners with Inclined Mantles: Single and Triple Fixtures.

Yet another novelty was recently described by M. Greyson de Schodt at the last meeting of the Société Technique du Gaz, and is alluded to in *The Journal of Gas Lighting.* This consists in the use of inclined mantles. The author points out that electricity has enjoyed a great advantage in the fact that incandescent glow-lamps can be inclined at any angle; this enables the polar curve of light distribution to be utilized to the best advantage. M. Greyson de Schodt utilizes an incandescent mantle flanked with a metallic reflector as shown in Fig. 1, and the angle of inclination can be varied to produce a wide variation in the polar curve.

However, this is not all. It is also pointed out that for street-lighting it is very convenient to use a cluster of mantles inclined at suitable angles. For street-lighting the possibility of altering the curve of light distribution to suit the local circumstances by adjusting the mantles in this way is regarded as a special convenience. A cluster of this kind is shown in Fig. 2. Any one or more of these mantles can

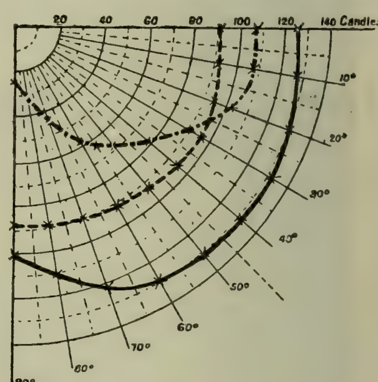


Fig. 3.
Distribution of Light from Greyson Burner.
— . — . — Greyson Upright Burner with Reflector.
— — — — Grätzin Inverted Burner with Reflector.
———— Greyson Inclined Burner with Reflector.

be extinguished if necessary, so that a reduced light and gas consumption can be utilized after a certain time in the evening, when the requirements of the traffic are less severe. Fig. 3 shows the nature of the polar curve of light distribution obtained from the inclined and upright mantle with the reflector. It is stated that by the use of inclined mantles in preference to upright ones the illumination on the pavement can be increased by more than two and a half times.

* *Illum. Eng.*, Lond., July, 1908, p. 582.
† *Illum. Eng.*, Lond., Jan., 1910, p. 63.

The Illumination of Workshops and Factories.

(Notes on the Report of H.M. Inspector of Factories for 1909.)

In the editorial remarks in our last number (p. 419) special reference was made to the recently issued Annual Report of H.M. Chief Inspector of Factories and Workshops for 1909. As explained therein, this Report was noteworthy for the special attention devoted to the illumination of factories and workshops, and we take this occasion of dealing somewhat more fully with this subject.

Previous Legislation on Illumination.

It is admitted that there is very little definite legislation on the lighting of factories and workshops. The early Factory Acts, it is stated, are silent on this point, and though the London Building Act of 1894, the Regulations for Docks (1904), and for Locomotives (1906) all contain certain recommendations for efficient artificial and daylight illumination, there are few detailed instructions as to the exact nature of what is necessary. It is, however, pointed out that, as explained in the report of the Conseil d'Hygiene de la Seine in Paris, to which reference has been previously made in these columns,* more explicit recommendations have been framed abroad, and Holland has even specified a definite standard of illumination of the order of 1 to 1.5 foot-candles for certain trades and industrial processes.

Importance of Good Illumination in Factories.

The report continues :—"The importance of adequate lighting in industrial employment is obvious ; as a matter of safety, especially where dangerous processes are carried on ; as bearing upon health in many ways, directly and indirectly ; and as a condition of efficient work. On the health side it is hardly necessary to point out that inefficient illumination entails risk, strain, and ultimate damage to the light, even apart from interference with work, or that it tends to neglect of cleanliness and adds to the risk of working in poisonous materials, or that it increases the need for artificial light, which can seldom be as satisfactory as daylight."

Yet the question of specifying standard conditions of illumination is beset with difficulties, and much investigation is necessary before definite recommendations can be made. Even daylight illumination varies very considerably according to the climatic conditions and the nature of the interior, and, although it is now possible to measure the illumination at a certain point in a room with sufficient accuracy, it is still uncertain what intensity of illumination is best suited for different classes of work. In the case of artificial lighting there are many other considerations to be borne in mind. In this connexion the report remarks : "As regards artificial light other considerations arise, apart from contamination of air by all except electric light and ventilated gas burners, namely, the quality of the light and the intensity of the source from which it is radiated, that is 'glare.' It appears that artificial light in which the rays from the violet (actinic) end of the spectrum predominate, may on that account be less efficient, at all events for certain kinds of work, and that radiation from a small but intensely luminous source, such as an unshaded electric light, may be more trying to the sight, and hence less effective, than the same amount of light diffused from a larger surface. In recent years much attention has been given to this subject by experts, and many important papers have appeared in *The Illuminating Engineer*, a monthly journal devoted to scientific illumination. The subject

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* *Ill. Eng.*, Lond., Vol. I., 1908, p. 811.

as affecting industrial employment is not one which admits of settlement by a stroke of the pen, and close investigation of the conditions will be necessary."

Illumination of Underground Premises.

A series of investigations have recently been carried out at the Factory Department on the conditions of underground bakehouses. It will be remembered that in the report of the Conseil d'Hygiene de la Seine special reference was made to the difficulty of securing adequate light and ventilation in many of the basements in Paris, and the table of results published in this report fully bears out the impression that the Illumination in many cases cannot be regarded as adequate. In the account of this work reference is made to a method of studying daylight illumination recently adopted by Mr. P. J. Waldram, and described in this journal.* This is based upon the suggestion that a certain relation exists between the illumination at a certain point in a given interior and the unrestricted illumination outside, which is practically independent of the climatic conditions. This fraction, the "window efficiency," as it is termed, varies very considerably in the different bakehouses studied, being more than ten times as good in the best lighted premises as in the case of the worst. It may be added that the actual value of the intensity of illumination recorded varies enormously —from 0.011 foot candle to 0.236—being, however, apparently in all cases quite exceptionally low. In bakehouses which were not underground better results were obtained, but still not all that could be desired. It should be added that these figures refer to the illumination in the darkest point in the bakehouses at which work was carried on. Figures are also given for three rooms in the Home Office on the second, third, and seventh floors respectively. The illumination in these three cases was 3.25, 0.30, and 0.92 foot candle respectively.

A number of inspectors comment upon the importance of illumination in these underground premises, and the difficulties also experienced in providing adequate ventilation. Thus Miss Martindale remarks :—"It is suggested that much might be gained for the future by systematic observations as to effect on health of various methods of lighting and construction, and that consideration might well be given to the age and physical condition of workers, and to the length of hours worked in places cut off from natural light. There is a world of difference between a basement workroom having large windows on to a spacious area with south or east aspect, and a deep vaulted room with narrow lights on to a street pavement, sometimes with a north aspect, or in a deep railway arch where daylight practically never penetrates."

Miss Slocock also describes certain small laundries in Soho and Mayfair in which the conditions as regards cleanliness leave much to be desired—a state of things which may be at least partially attributed to bad illumination.

Illumination and Eyesight.

There are a number of other instances of the need of good lighting mentioned in the body of the report. Conditions of space prevent our referring to these in detail. We may, however, mention the report of Mr. Walmsley (Manchester), who, as a result of inquiry into the lighting of rooms in cotton and textile factories finds that out of 781 persons examined 16.9 per cent. wore spectacles ; he adds that "such work must be trying for the eyes, consisting as it does in manipulating fine threads all day long, drawing them through the small healds and reeds, and good lighting is therefore most desirable. Our powers in this direction are limited, but occupiers have been found very ready to consider suggestions, and we have in this way been able to secure improvements."

We regard this last remark as of special interest. It illustrates the truth of our contention that at the present time advice and help would often be valued by those in charge of factories, who would like to improve the conditions of lighting, but are uncertain how to proceed.

* *Ill. Eng.*, Lond., Vol. II., 1909, pp. 229, 319.

Injury to eye-sight is also referred to by Miss Paterson. In commenting upon photographic processes she says: "Retouchers of negatives in photographic workshops appear to suffer from injury to eye-sight if the work is continued too long at a time. In only one case of the twenty-two visited were the conditions definitely and conclusively unsatisfactory. In this place, the women and young persons (five) were kept at work continuously at retouching by artificial light. The negatives only were illuminated (by electric light), the rest of the room being kept in darkness. The workers complained very much of the effect on their eyes; even the wearing of glasses did not prevent them from feeling sore and aching. Good lighting is necessary to this work, daylight, when it can be used, being preferred, both for the sake of the works and workers. Three or four hours' work with artificial light appears to be sufficient to make the eyes ache. Glasses which magnify very slightly are frequently worn by the workers. In most cases, the retoucher does other work as well, and when her eyes begin to ache she goes to other work."

Temperature and Ventilation, &c.

There are also trades in which special difficulties arise and have to be guarded against. An instance is provided by the incandescent mantle industry. Dr. T. M. Legge refers to the unpleasant effect on the workers from the vapour arising from the baths in which the mantles are dipped, and from excess of carbon dioxide generated in the process of seasoning. Miss Paterson refers to the overcrowding in factories of this kind, and to the excessive temperatures which are sometimes found in rooms.

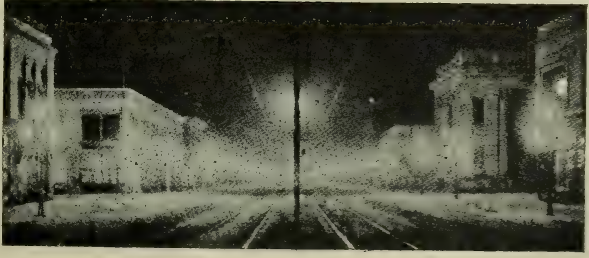
Safe Handlamps and Plugs.

Finally we may note that this report also contains some remarks on the safety hand lamps. It will be recalled that in a previous report a style of lamp was described which avoids the risk of shock associated with the ordinary arrangement; and it is satisfactory to note that lamps with the requisite qualification in this respect are coming into more frequent use. The present report also contains a suggestion regarding an improvement in insulated plugs from the standpoint of safety.

Accidents are also reported from the misuse of naptha lamps, and a form of apparatus resembling the wire gauze in the Davy miners' lamps has been utilized with effect in this case. Gauze of this kind prevents fire from an outside source penetrating to the mixture of air and oil-vapour within the vessel. Mr. Newlands (Dundee) states that on some occasions he has seen ether being poured, while on fire, from one vessel to another, and yet the flame was unable to reach the explosive vapour in either.

Series Street Lighting with Tungsten Lamps.

The accompanying illustration shows a street in Gary, Indiana, U.S.A., illuminated by tungsten lamps in series. The circuits are supplied with a constant current from 2200 volts 25 cycle secondaries. A feature of interest to illuminating engineers is that the power is provided by the great blast furnace gas-driven station in this locality, both gas and electricity thus taking their share in providing the requisite illumination. Each lamp is provided with a special cut-out. The posts are spaced 50 ft. apart, and each carries two 60 watt and one 100 watt lamps. (These particulars are taken from *The Electrical World* of New York, June 30th, 1910.)



The Light of the Fire-Fly.

(Abstract of a paper presented by H. E. Ives and W. W. Coblentz, at the third Annual Convention of The Illuminating Engineering Society in the United States, September, 1909.)

THE considerable amount of study which has been devoted to the radiation from commercial sources of light during recent years, has been admirably summarized in the series of articles which Dr. W. Coblentz has recently been contributing to this journal. They lead us to the conviction that the percentage of energy in a visible form furnished by most sources is deplorably low. It is therefore interesting to notice some of the results of the above two authors on the light of the fire-fly, a source which Langley and Very* long ago showed to be extremely efficient.

In the present investigation, the distribution of energy in the spectrum of the light yielded by the fire-fly was investigated. In studying this matter Langley and Very relied mainly on spectro-photometric and radiation tests. Ives and Coblentz, however, preferred to utilize a photographic plate, sensitive to the whole visible spectrum, and for the following reasons.

With the radiation meter it is possible to measure radiant energy in the visible spectrum directly, provided the source measured is steady and has sufficient energy to affect the instrument. But the available energy must be considerable, since instruments of this kind are many thousand times less sensitive than the eye or photographic plate for radiation less than $\cdot 65\mu$ in wavelength. With the spectro-photometer it is possible to measure the distribution of visible radiant energy, even if of low intensity, indirectly, by comparing the source with one of known energy distribution, provided again the source measured is steady. But if the source measured is unsteady as well as weak, neither method of measurement is applicable. For cases of this kind the photographic plate as a record of incident energy is the only resort.

* Am. Jour. Sci., 3rd Series, Vol. XI., No. 236, 1890. Reprinted, Smithsonian Misc. Coll. No. 1358, 1901.

A number of peculiar difficulties were experienced in getting a sufficiently strong light from the insects studied. It was at first attempted to secure sufficient light by enclosing a number of the insects in a small cage with a white wall from which the light would be reflected into the slit. It was soon found, however, that fire-flies in captivity quickly lost their desire to flash, and this scheme was abandoned. The only satisfactory method proved to be to hold the insects in the fingers one or two at a time over the spectroscope slit. The best specimens would flash as frequently as every three seconds until tired, when others would be substituted for them. Others, after a period of flashing, would yield a steady glow of considerable intensity. With a fairly wide slit, exposures to the fire-flies, taking them as they came, amounted to from two to six hours.

The light of the fire-fly is confined to a continuous band in the yellow-green, ending in the blue-green on one side, in the red on the other. The distribution of energy was obtained by a study of the photographic plates thus exposed. In order to interpret these results correctly it was also necessary to carry out a special series of researches enabling the authors to obtain the relation between density and intensity of light; this having been done it was found possible to compare the curve of energy distribution of the fire-fly with that of an incandescent glow-lamp by spectro-photometric means.

The result of this investigation is shown in Fig. 1. It will be seen how greatly preferable, from the standpoint of light production, is the curve of the fire-fly.

It will also be noted that the maximum of light-emission is in the part of the spectrum to which the eye is most sensitive, the yellow green, at $0{\cdot}57\mu$ and the extent of the spectrum is from $0{\cdot}5\mu$ to $0{\cdot}67\mu$. Very much

longer exposure might have shown greater length.

As a result of a comparison of the radiation curves of different illuminants, the authors gave the following figures for the percentage of radiation which occurs in the visible form :—

wastefulness of artificial methods of light production. From the specific consumption of the tungsten lamp (1·6 w.p.s.c.) and the mercury arc (0·55 w.p.s.c.) we obtain by comparison with the carbon filament that their luminous efficiencies are 1·3 per cent

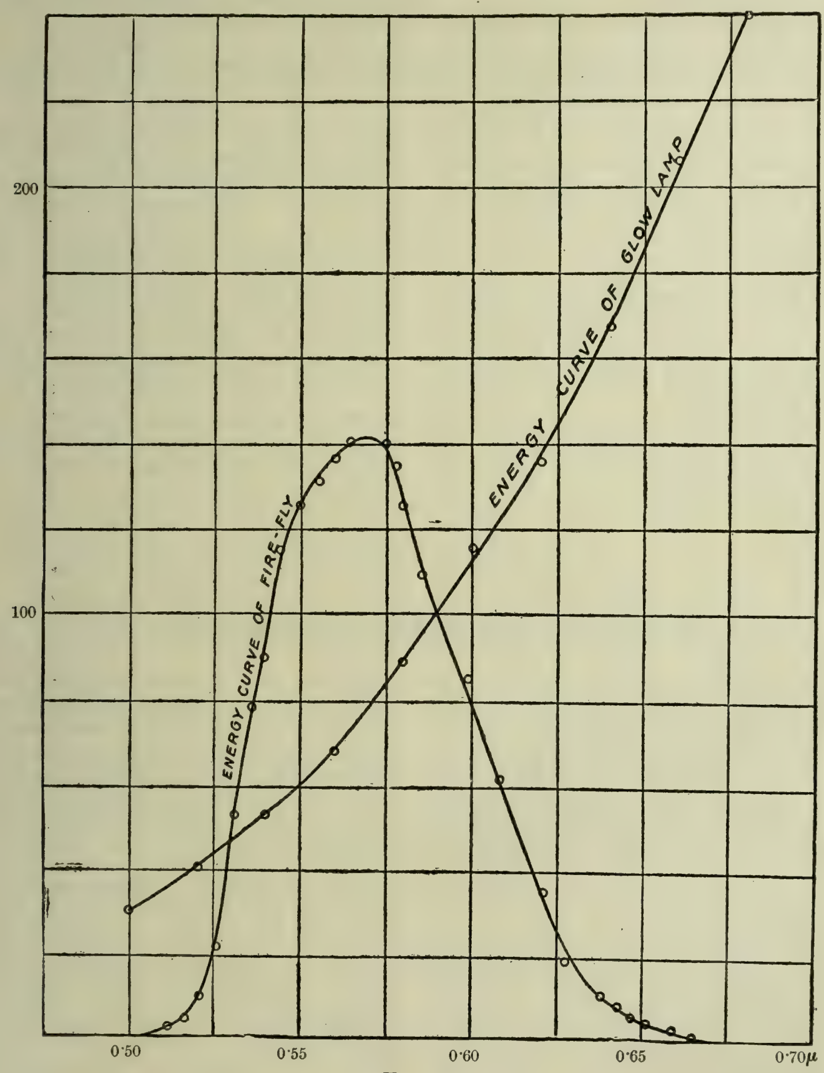


Fig. 1.

For the glow-lamp it is 0·43 per cent : for the fire-fly 96.5 per cent, these numbers representing the relative amounts of light (measure in a photometer) for equal amounts of radiated energy—a striking illustration of the

and 3·8 per cent. The most efficient artificial illuminant therefore has about 4 per cent of the luminous efficiency of the fire-fly.

It must, however, be remembered that although the efficiency of the fire-

fly is so high, its light would certainly be a very peculiar colour for ordinary practical purposes. Under ordinary conditions we require a light of an approximate white character.

The most efficient light for human use, taking into account both colour and energy-distribution, would be a light similar to the fire-fly light in containing no radiation beyond the visible spectrum, but differing from it in being white. It should possess an energy distribution in the visible spectrum similar to that of a black body at about 5000° Centigrade, but falling to zero sharply beyond the limits of visibility.

The authors also comment upon the desirability of studying these phosphorescent substances which may eventually enable us to produce sources of light vastly more efficient than those at present available.

In a more recent contribution* W. Coblentz gives the result of some further experiments on the phosphorescent material isolated from the fire-fly. He also points out that although the light yielded therefrom is of an unsuitable colour for ordinary purposes, it might be possible to obtain other phosphorescent substances giving a light which is complementary with that of the fire-fly, so as to produce a fairly white light. The variety of fire-fly studied yields light of a greenish character. There are, however, published results which suggest that insects are in existence containing phosphorescent materials which give red and blue light. The examination in detail of the phosphorescent material which occurs in these insects might lead to very valuable results could we but produce by artificial means large quantities of similar material. In this way we might eventually obtain a substance which would give us not only a brighter light, but also of a more serviceable colour.

* Physikalische Zeitschrift. No. 10, 1909, p. 955.

Improvements in the Quartz Lamp.

In a recent article in the *Elektrotechnische Zeitschrift* some particulars were given of the working of the latest form of the Küch Quartz Lamp. This mercury vapour lamp, it will be remembered, utilizes a special quartz-glass tube by the aid of which a temperature between 5,000 and 6,000° C., and a consumption between 0·2 and 0·3 Watts per candle-power (Hefner) are said to be obtained. Some description is also given of the mechanism of the lamp which, however, is only intended for starting purposes, and is thus essentially simple in construction.

When the lamp is started sufficient mercury has to be volatilized to maintain the arc, and the process of tilting the the tube may be repeated, until the correct conditions within it are secured. But if the quantity of air in the tube ever becomes too great it may not be possible for the lamps to start up properly.

A resistance consisting of iron wires in an atmosphere of hydrogen, is placed in the lamp-circuit and built into the lamp itself. After burning a little time the resistance of the lamp changes, and is then counterbalanced by a corresponding alteration in the iron resistance. A choking coil is also included in the circuit to compensate for the effect of any temporary fluctuation in the supply P.D., to the effect of which the lamp appears to be somewhat sensitive. Another interesting point in connexion with the lamp is the variety of metal used for the electrodes let into the quartz tube. The glass has a zero temperature co-efficient of expansion, and therefore a metal likewise having a zero temperature co-efficient must be used; a variety of nickel steel appears to satisfy this requirement.

The present 100 volt lamp consumes about 4 amperes, and is credited with 1,200 candle-power (Hefner). For voltages between 200 and 250 lamps taking 2·5 amperes and 3·5 amperes, and giving 1,500 and 2,000 candle-power respectively are made.

It is also stated that four patterns of lamps for indirect interior lighting are being constructed.

The Work of Dr. Carl Auer von Welsbach in the Field of Artificial Illuminants.

By Prof. G. S. Barrows.

(A paper presented at the Third Annual Convention of the Illuminating Engineering Society, New York, September 27, 28, 29, 1909; abbreviated.)

Among the few names indissolubly connected with the development of artificial illumination, that of Welsbach is deservedly prominent.

Before his time the production of light by means of a body rendered incandescent by the heat of a gas flame, had been the goal of many inventors for over a century, working on lines which differed only in detail, as to the kind of gas used (hydro-carbon, oxy-hydrogen, &c.), the substance to be heated (a refractory metal or oxide), the form of the body and manner of applying the flame. With the exception of the Drummond light (an oyx-hydrogen flame on a pencil of lime) none of the various lamps was more than evanescent, and even the Drummond light was strictly limited in its application.

Dr. Carl Auer Baron von Welsbach was born September 1st, 1858, the youngest son of Alois Ritter Auer von Welsbach, a celebrated typographer and the director of the Court and State printing office of Austria.

His chemical studies were persued first at the University of Heidelberg under the celebrated Dr. Bunsen, and later under Prof. Liben at the University of Vienna.

In an address delivered by Dr. Welsbach before the Deutscher Verein von Gas und Wasserfachmännern in 1901, he gives an interesting account of his early work, from which we may abstract the following: About the year 1880, while a student in the University of Heidelberg, he was occupied with the chemistry of the rare earths, being particularly interested in the separation of didymium into its components—neodymium and praseodymium, and the study of erbium-oxide.

It was the remarkable behaviour of this latter rare substance and its glowing flame that particularly drew his attention, the peculiar striped spectrum being very unusual. The small beads gathered on a platinum loop not giving a sufficiently bright spectrum, it occurred to him that it might be possible to saturate a piece of cotton webbing with a solution of the salts, and then burn out the cotton, leaving the oxide of the earth. Much to his surprise, he found that this experiment was more than a success, for the earths retained the form of the webbing to an extent not considered possible by him.

The first mantles were not made in the present form, but were produced by sewing a piece of relatively loose net webbing into a cylinder, and then saturating this cylinder in the desired salts. The first mantle made in this way from lanthanum oxide was apparently perfect, but Welsbach was very much disappointed to find, after a few days, that the mantle, which had been carefully put away, had crumbled to a powder. It was at this time that his skill as a chemist and perseverance as an inventor stood him in good stead. He immediately made up his mind to combine the lanthanum oxide, which had high light-emitting qualities, with another substance which would not slake and disintegrate so easily by absorbing water vapour or carbonic oxide from the air. Magnesia was decided on as being the best material known at the time, and from a mixture of lanthanum and magnesia a much better mantle than the first was made, which did not crumble to dust and which gave a fair light, but which, after a few days' burning, lost its peculiar

porous structure, becoming glassy and also shrinking badly.

This, while far in advance of the first mantle, was still a mere experiment, so it was necessary for him to go further, and his next experiments covered some of the zirconium oxides. These zirconium mantles gave very much better results, as they were somewhat more efficient, and retained their shape for a period of several hundred hours. Continuing his experiments with various earths, he was surprised to find an extraordinary increase in the intensity of the light when thorium oxide was added, and it was of these materials that the first commercial mantles were made in the laboratory of the University of Vienna and exhibited to the public in a lecture before the representatives of the Vienna press in January, 1886.

The burner was very awkward in appearance, having a very long bunsen tube, and a very high chimney. Lamps of this description were the first commercial lamps placed on the market, and they were put out in practically every country of the world where manufactured gas was used. The efficiency of these lamps was from 10 to 15 candles to the cubic foot of gas, and the depreciation in candle-power was considerably greater than it is at the present time, although there are records of their early mantles burning for a period of over 20,000 consecutive hours, and giving at the end of that time an efficiency of nearly 10 candles to the cubic foot.

The next few years were, comparatively speaking, years of considerable commercial development in the line of the incandescent gas light, Dr. Welsbach being employed in directing the operations of his large chemical laboratory in Vienna, where the fluid for impregnation of the webs was made for all of the companies of the world.

For several years the lamp was more or less of a novelty, but after this novelty had worn off, and it was seen that the efficiency of the lamp was not sufficiently greater than that of other illuminating devices to pay in any great degree for the annoyances experienced by the breakage and shrinkage of the primitive mantles, the demand for the lamps fell off to some extent, and for some time the fortunes of all the incandescent companies were at a low ebb. The fabric base for the mantles at this time was all made on a stocking knitting machine, knitting mantles into the form with which we are familiar now, but the fluid in which they were saturated, was the same fluid that Dr. Welsbach had been making at the first.

The next improvement which he made in the mantle was to reinforce the head of the mantle where it was gathered, sewn, and attached to the mantle carrier. He strengthened the mantle by dipping the fabric for a short distance down from the top in a different solution of refractory earths, the oxides of which had greater powers of coherence, and which became harder than the lighting oxide, although they did not affect the light-giving qualities of the earths used in the manufacture of the body of the mantle. He also invented a scheme for regenerating mantles, that is, for recoating the oxide structure after the candle-power of the mantle had begun to fall off with a solution of the oxides, particularly those of lanthanum. This regeneration was to be accomplished either by applying the solution to the mantle by means of a brush, by spraying, or by allowing the solution to drip on the mantle, and by capillary action to cover all of the structure. While this scheme may have been tried in practice, it has certainly never come into wide commercial use. An interesting patent granted to Dr. Welsbach was for the strengthening of mantles for purposes of transportation. He coated the finished mantle with a salt of the rare earths, particularly mentioning lanthanum, and on subjecting this recoated mantle to ammonia vapour, a hydrate was formed in the pores of the mantle, which made a gum-like, or elastic and coherent mass. This coating when burnt was converted to the oxide, and did not in any way interfere with the light-giving qualities of the mantle. At this time the mantles were not transported in the way with which we are familiar

at the present time. In fact, very few mantles were sent out alone, the general practice being to mount the mantles on the burners and take around a lamp complete for installation. When a mantle already in use was broken, this meant that not only the mantle was replaced, but the entire lamp was replaced, the burner which had been in use being taken to the office of the company and refinished if necessary, before being sent out a second time.

In spite of these various improvements, the business did not develop, until Dr. Welsbach by a fortunate chance, made a further discovery.

By accident there was a quantity of raw thorium oxide in the factory at the time he took it over. He worked on this material, which at that time was precious and scarce, and discovered a new method of preparing thorium salts—the method of crystallization—which enabled him to manufacture thorium inexpensively and in large quantities. During the process of crystallization, he noticed the remarkable phenomenon that the purer the thorium became, the less light it would give off if formed into an incandescent mantle. Continuing the experiments, he found that with the purest thorium oxide he could prepare, the mantle gave practically no illumination. This convinced him that thorium was not the element which of itself gave the light, but he would find this element in the drainings which were left from his various crystallizations. In the drainings of the purest fractions, he could not find any foreign elements, but working backwards, he finally found that cerium was the salt which he should use, and it was not long before he was able to determine the best proportion of thorium and cerium, which from that time to this has been the standard mixture for incandescent mantles. This mixture, as is well known, consists of 99 per cent. of thorium oxide and 1 per cent. of cerium oxide. This discovery was made about 1890, and at once the incandescent mantle business began to gain in enormous strides. The factories increased their outputs in all of the countries of the world, and the incandescent mantle became a commercial article in every sense of the word.

There have been many explanations offered for the extraordinary increase of light of thorium oxide when a small proportion of cerium oxide is added to it. Dr. Welsbach's idea is that the incandescent bodies, which are capable of emitting an intensive light in the bunsen flame, consists of a molecular mixture of oxides. Quoting again from his address: "The principal part of these bodies has got to remain unchanged in the flame, whilst the other one, the smaller part, must have the property of being easily alternately oxidized and reduced. The proportions of these two elements seem to depend on the pressure under which they are to work; for our atmospheric pressure the percentage is 99 per cent thorium and 1 per cent cerium. Under a pressure of 100 atmospheres, I suppose the percentage of the cerium would have to be larger. The gas of the flame alternately oxidizes and reduces the incandescent mantles in quick succession. If those combinations have the property of combining with each other at a certain stage of oxidation of the variable element (cerium in our case), then they will have to fall apart if the latter element changes into the other form of oxide. Assuming that the one element (cerium) for instance combines with the other (thorium) when the former has reached the stage of higher oxidation, then they must fall apart if the cerium is deoxidized again, or has assumed a lower stage of oxidation. This separation takes place suddenly. The earths are most finely divided and touched alternately by the oxidizing and reducing gases of the flame. If reduction takes place, the oxides are separated. If oxidation takes place, they again combine. This separating and combining may occur millions of times in a second. Thus molecular vibrations are set up which are the cause of the ether wave of the light. Therefore the incandescent mantle emits light.

Since the date of this address, there have been numerous articles explaining

the incandescence of mantles, and reference is made to the above to state Dr. Welsbach's position on this subject, which I believe has not changed.

Dr. Welsbach's best-known invention outside of the incandescent mantle, has been the osmium filament for electric incandescent lamps. About 1898 Dr. Welsbach succeeded in producing his first incandescent lamp, which immediately became of the greatest interest to the scientific world, because a metal filament was satisfactorily employed.

Undoubtedly, his success with the incandescent lamp influenced him very largely in the experiments which he performed to produce the osmium filament, for his first filaments were made in a manner somewhat similar to that employed in making the incandescent mantle. He coated a thin metallic wire, such as platinum, in various ways, and gradually raised this coated wire to a very high heat in a vacuum or in a protective atmosphere, driving off the platinum in the form of a vapour and leaving the osmium in a coherent thread or tube. He coated the platinum wire in various ways, such as—(1) the osmium was deposited on the wire by heating the wire in a reducing atmosphere containing osmium vapour ; (2) by electric deposition in a bath containing a salt of osmium ; (3) by applying a paste containing evenly divided metallic osmium. In the latter case it was necessary to make many applications of the paste in order to get the required thickness.

Companies for the manufacture of the osmium lamp were formed in various countries, but the lamps never came into general use, although a number of them were installed and are still in use in Vienna. In all probability if the tantalum and tungsten lamps had not been invented, the osmium lamp would now be occupying the place held by these latter lamps. Dr. Welsbach is certainly the pioneer in the field of metallic filament lamps, and we can well give credit to him for the work which he has done with the osmium filament, which has led to the development of the other metallic filament lamps.

Dr. Welsbach is still continuing his chemical research, and has recently taken out patents for a pyrophoric substance.

Investigators of the rare earths have long noted the property of rare earths in giving off particles when scratched with a hard substance which would become ignited in the air. Dr. Welsbach investigated this field, and soon became convinced that these rare earth metals only became pyrophoric when alloyed with other metals, particularly iron. Nickel, cobalt or manganese may be used with the iron, but some iron must always be used. The alloy of the rare earths with the iron is made in the form of a paste, the binding material removed, leaving a substance which more or less resembles a stone. This substance when scratched with a sharp piece of iron or steel (a file for, instance), will give off sparks. These sparks, which do not seem to have very much heat, and which do not produce smoke, may be given off in the form of large flames, particularly when lanthanum is used, which flames produced in the focus of a reflector, may be used for flashlights for signal purposes. This, however, has never been done in practice. When cerium is used, smaller sparks are produced, which seems to be better for the purposes of ignition. The development of this pyrophoric material may, it is likely in time, lead to its application to gas burners, as well as to its use with cigar lighters and other portable lighting appliances. Up to the present time, its use has not been a commercial success, but its favourable development is apparently only a question of time.

This account, necessarily short and incomplete, may serve to give to many who only know him as the inventor of the Welsbach mantle, an idea of the many achievements of Dr. Welsbach ; we may well watch with interest the research that he is now carrying on, being assured that we will yet gain from his investigations, either in the field of illumination by the generation or conservation of the electrical energy, or in that wide field in which he originally commenced his work—that of pure chemical investigation.

Pyrophoric Ignition Devices.

By Dr. C. R. Böhm (Berlin).

One of the earliest and most important steps in the progress of the culture of nations was the knowledge how to produce and utilize fire and light. Of the efforts involved in the gradual development of facility in this direction we to-day have only a very imperfect conception. In this article only a brief reference to the development of the tinder box and early methods of kindling fire is possible ; and attention will be paid mainly to some of the more important devices in use at the present day.

It is most interesting to observe how, in this matter, as in many others, we have reverted to the very earliest methods. Pyrophoric devices of to-day are nothing more or less than a development of the old tinder box, in which a spark could be produced by striking together appropriate materials. The sparks originally produced were weak and uncertain, and failed to kindle the tinder. Subsequently men learnt to make use of steel and pyrites, and by so doing produced larger sparks, small particles being broken away and brought to incandescence by sustained friction. The modern process is the same, except that we now utilize the mineral cerite, which yields sparks much more easily than steel and iron. The word "pyrophoric," strictly understood, means "self kindling in the air," so that the use of this term to denote production of sparks by rubbing is merely a later derived meaning.

In the *Chemiker Zeitung* (1910, Nos. 41 and 43) I have shown that the existence of the pyrophoric metal cerite has long been known. The only difficulty lay in producing the substance in sufficient quantity. Muthmann and his students have devoted special attention to this problem, and have shown how larger quantities of this material could be readily produced by fusion and electrolysis. This question was taken up by Auer, who applied for a patent covering the use of alloys of cerite with heavy metals and also their manufacture. However, several years passed before Auer realized the practical bearing of this idea. He was subsequently impressed with the value of alloys of this material with iron, but he was not the first to succeed in producing a pyrophoric kindling device ; this was first accomplished by some one in Vienna, who had become possessed of a piece of the Auer metal, and devised a pocket kindling apparatus in a cartridge form. This led Auer to appreciate the importance of his discovery, and his German patent was subsequently sold for 600,000 marks to a newly formed Company in Cologne. Meantime the pyrophoric kindling device originated in Vienna developed rapidly, and, as was only natural, keen competition was entered upon shortly afterwards. Since it was already known that pyrophoric properties were not only confined to cerite, but also to its alloys with various metals, and as moreover the process of Muthmann and his students had already been published, it was almost inevitable that objections should be lodged against Auer's patent, and several firms joined in contesting it. Now even the greatest scholars have been known to make mistakes, and it seems possible that Auer, who was originally misled in the interpretation of his discovery of the incandescent mantle, might also be wrong in his explanation of the pyrophoric qualities of metal cerite.

In opposition to all previous investigators Auer had found that the *pure* metal cerite did not possess pyphoric qualities, and that this effect was to be ascribed to the presence of iron. Yet he seems afterwards to have modified this opinion, for in a note in the *Journal für Gas-*

beleuchtung und Wasserversorgung he stated that 2 per cent of iron had no effect on the physical qualities of properties of metallic cerite. He subsequently sought yet another explanation of the pyphoric effects characteristic of cerite, and was thus led to the theory of the lower oxides, which forms the basis of more recent patent applications.

However, the Patent Office has recently annulled Auer's second patent claim relating to the manufacture of cerite alloys, and has also decided that the first general claim was limited to mixtures with heavy metals in proportions of the order of 30 per cent.

The use of light metals as alloys of cerite is not mentioned in the Auer patents, but has been been specified by Kunheim & Co. But as a result of several objections this patent has also recently been annulled, so that to-day there is no longer any monopoly in pyrophoric materials.

A third possibility of producing pyphoric substances is illustrated by the so-called Lucium Patent, involving a loys of cerite with certain metalloids. The efforts of Krieger to produce pyrophoric alloys containing no cerite have as yet merely led to materials which only spark satisfactorily under certain restricted conditions.

In reality the question of the priority of inventor of the pyphoric ignition devices is a somewhat complicated one, since, as we have seen, a number of inventors besides Auer were early in the field, both in the production of sparking materials and in the more practical problem of producing a device of industrial value. Julius Pintsch certainly constructed the first gas-lighting device based on this principle. The Pintsch's patent thereon was subsequently allowed to lapse, because the material available at this time deteriorated in air and gradually became reduced to powder. But it was only afterwards when he had succeeded in making the cerium-iron alloy more durable, after Richard Kohn in Vienna had produced the first pyrophoric pocket igniter, and Russbacher had disposed of the Horváth igniting device, that Auer recognised the possible applications of the metal cerite. It is rather remarkable that the igniters on the market in Germany are still inferior in exact workmanship to those manufactured in Vienna.

These pocket ignition devices have rapidly become very popular, and will continue to hold their position in the future. Already their competition with the match box is becoming keen, and the large number (about 300) of different patterns in use illustrates the interest that is taken in the subject. It is only free competition that has enabled this rapid development to take place. It is also of interest to observe that the most recent types of gas lighters make use of the Kunheim improved and fairly soft material, while the very durable and hard Auer material is exclusively employed for the pocket apparatus.

Notes on the Lighting of an Art Studio.

By An Engineering Correspondent.

It is a truism in illuminating engineering that each problem requires special consideration. The lighting of art studios is a very good example. In many polytechnics and institutions throughout the country there are art classes held in the evenings when artificial illumination is essential. Now it is difficult to imagine a case in which good lighting is of greater importance. For in drawing and sketching the eye is being constantly used in a most exacting manner. The student must probably study the detail of his drawing much more closely, for example, than does a reader the printed type on the page. He has also to inspect the model from which he is drawing very carefully. Therefore not only should the intensity of illumination on his paper be ample, but the illumination of the model should probably be higher than that

of the surroundings, and the light should come from the right direction, so as to give the necessary play of light and shadow. One might suggest, for example, that a shadowless indirect system of lighting, however satisfactory for other purposes, might here prove unsatisfactory.

However, when one pays a visit to night schools, where art classes are held, one is struck by the varying standard of illumination and the exceedingly different views that are apparently held as to the arrangement of the lights. This seems to be mainly determined by the caprice of the master.

It therefore occurred to the writer that some notes on the lighting of an art school which recently came under his notice might be of interest. The dimensions of this room, 42 ft. long by 22 ft. broad, will be noted in Fig. 1. The work carried out consisted mainly of "life" and figure drawing, modelling, &c. The original method of lighting consisted in four fixed pendant fittings,

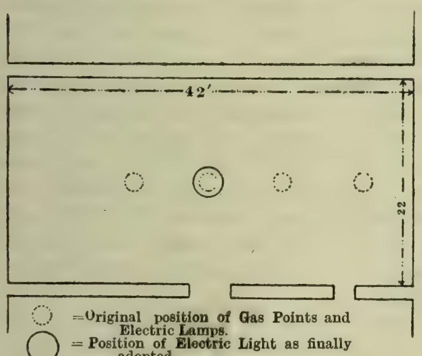


FIG. 1.

each equipped with five incandescent mantles rated at 50 candle-power, arranged as shown by the dotted circles in Fig. 1, the height from the burners to the floor being approximately 14 ft.

Subsequently it was decided to adopt electric light, and three ampere 240 volt Luna Nernst lamps,* each equipped with an opalescent globe, were installed. The lamps were hung 15 ft. above the floor, and spaced at regular intervals down the centre of the room. To these a fourth unit, consisting of three 16 c.-p. carbon filament glow-lamps, under an opal shade, was added. This was attached to a long length of flex, so that it could be moved about to concentrate the light at any desired point, *e.g.*, to illuminate the model with special intensity or to throw certain shadows, &c. Experience showed that this arrangement was not entirely satisfactory, partly because the failure of one of the Nernst lamps diminished the light in that locality so much as to necessitate a rearrangement of the work in the vicinity. Finally the three Nernst burners were collected together in a special fitting under an enamelled iron shade, 36 in. in diameter. The entire fitting was hung by three iron chains attached to the outside rim of the shade, these being again attached to a single chain suspended from a cross beam in the roof. This fitting was placed at a height of 15 ft. 6 in. above the floor.

This method has given great satisfaction. It may be added that each of the Nernst lamps in the fitting is separately controlled, so that any number can be switched on as may be desired. The light is very steady, and apparently of a desirable quality from the artist's standpoint. In view of the great progress of the metallic filament lamp this example of one case in which the Nernst lamp has proved of value is not without interest. F. H. T.

Aeronautics at the Northamption Polytechnic Institute.

THE silver medal offered by the Women's Aerial League to the best student in the pioneer courses in Aeronautics, held during the session 1909-10, has been awarded to Mr. Duncan George.

COURSES of a more complete nature are being arranged for next session under the supervision of Mr. F. Handley Page. In addition, there is under consideration the establishment of full-time day courses in Aeronautical Engineering extending over four years, and similar to the well-known day courses in Electrical and Mechanical Engineering established some years ago

Notes on the Testing of Incandescent Mantles, Electric Glowlamps, and Arclamps, &c.

By an Engineering Correspondent.

(The following notes are taken from a revised copy of a paper which secured the "Durham Bursary" for 1909-1910 and are published by the kind permission of the Junior Institute of Engineers. The paper in question also contains a summary of the principles of light-production, historical notes on the development of different methods of lighting, and a discussion of photometers, &c., which, however, will be familiar to readers of this journal from previous articles on these subjects. It is interesting to note that a paper devoted to the discussion of Illumination as a whole should have been awarded the Bursary referred to, and this may be regarded as one more instance of the growing desire to stimulate investigations on all matters connected with illuminating engineering.)

(*Concluded from p. 461.*)

Life Tests (continued).

The following table shows the life test of a tantalum lamp (published in *The Electrical Field*, Vol. 1, p. 292) :—

Hours.	Candle-power H.K.	Current in Amps.	Watts per H.K.
0	25·7	·36-·38	1·5-1·7
5	28-31	·37-·39	1·3-1·5
150	25-27	·36-·38	1·5-1·6
300	22-24	·36-·38	1·6-1·7
500	20-22	·36-·38	1·9-2·0
1000	18-20	·35-·37	2·1-2·2

A test carried out by the Sirius Co. on a lamp of their manufacture called the "Sirius Colloid" is given below. The lamp is made by the "Kuzel" process, and the exceedingly homogeneous filaments produced stand very large fluctuations in voltage without appreciably reducing the life of the lamp. The test was published in *The Electrical Field*, February, 1909.

Hours.	Candle-power H.K.	Current in Amps.	Watts per H.K.	Percentage change in cp.
0	13·5	0·470	1·05	0
467	12·1	0·465	1·11	-10·4
1460	12·0	0·470	1·09	4·4
2188	13·5	0·470	1·05	0
3103	14·0	0·480	1·03	3·7

Adjustable Lamp-Holders.

There are several forms of adjustable lamp-holders used in the determination of spherical measurements, by which the lamp tested can be turned through any required angle, but all the apparatus for this purpose has, as far as the writer is aware, the disadvantage of not allowing measurements to be obtained within a range of 60° around the hold of the lamps. The dotted portions of the curves in Figs. 1 to 4, indicate positions where, by the aid of such apparatus, correct readings could not be made. Although these readings in many cases are very low, it is desirable that their correct value should be obtained, and Fig. 5 shows a suggested arrangement to enable correct readings to be taken with the lamp in any position. A section of the holder has a pointer P fixed to it, which will move over the scale Q. Thus the angles can be adjusted for horizontal measurements ; the thread on which the holder turns must be fine, so that no appreciable difference is made in the leve of the lamp when turned through an angle. The slit O in the support is made as narrow as possible (but must allow the flex to pass through easily), the object of this slit is to enable the holder to be removed without disconnecting the flex. By means of a second scale fixed as shown, vertical angles can be adjusted, and thus by fixing the support to any suitable form of stand, the lamp can be turned through any angle in the horizontal and vertical planes.

An adjustable electric lamp spinner is made, in which the lamp is continuously rotated in the horizontal plane, whilst periodic photometric readings are taken at different angles on the vertical scale. If the current remains constant, each reading will represent the mean intensity around the lamp at that particular angle, and thus the mean spherical candle-power can be determined with one set of measurements.

Tests of Arc-lamps.

In making photometric measurements of arc-lamps special devices have to be adopted, the dimensions of the lamps in many cases rendering the

usual forms of testing apparatus unsuitable. Photometers are constructed which can be adjusted to any angle suiting the position of the lamp, but good readings are difficult to obtain as the crater of the arc changes in position, and consequently increases or decreases the light intensity at the point of measurement. A convenient arrangement for determining the mean spherical candle-power of an arc-lamp, a diagrammatic view of which is shown in Fig, 6, has been designed by Dr. Drysdale at the Northampton Institute.

The lamp is rotated by means of a small motor, and at the same time photometric readings are taken at different vertical angles ; thus, as in the case of the lamp spinner previously mentioned, each reading will represent

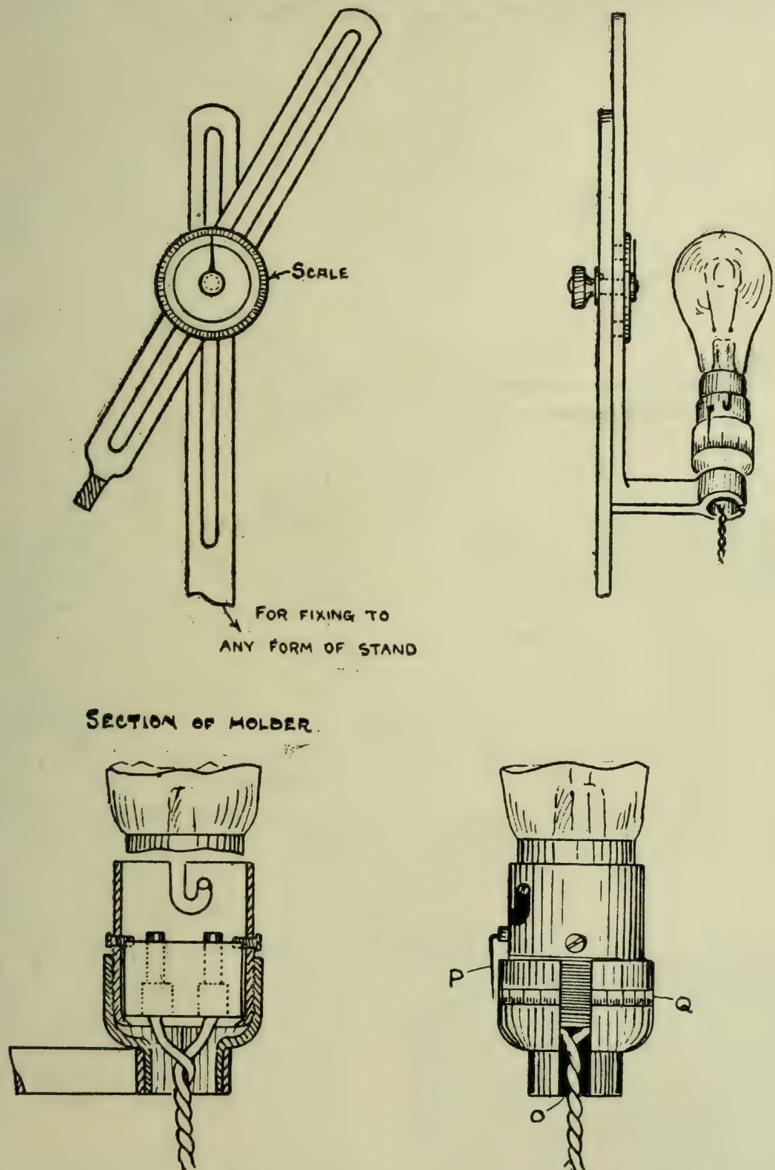


FIG. 5.—Adjustable Lamp Holder.

the average candle-power around the lamp at that particular angle; the mean spherical candle-power being easily determined from one set of readings. The apparatus is easily operated, and the rotation of the lamp minimises the trouble experienced with the crater of the arc changing in position.

Fig. 7 shows the polar curve of an "Excello" arc-lamp (with globe), the test being made by the use of the above arrangement; tests were also made which indicated light absorption by the globe to the extent of 9–10 per cent.; the globe, however, effects good diffusion of the light.

In conclusion, the writer wishes to state that all tests and experiments indicated, have been performed at the Northampton Institute, Clerkenwell, E.C., where information has also been gathered from lectures delivered by Dr. C. V. Drysdale, and Mr. S. Fields.

F. J. H.

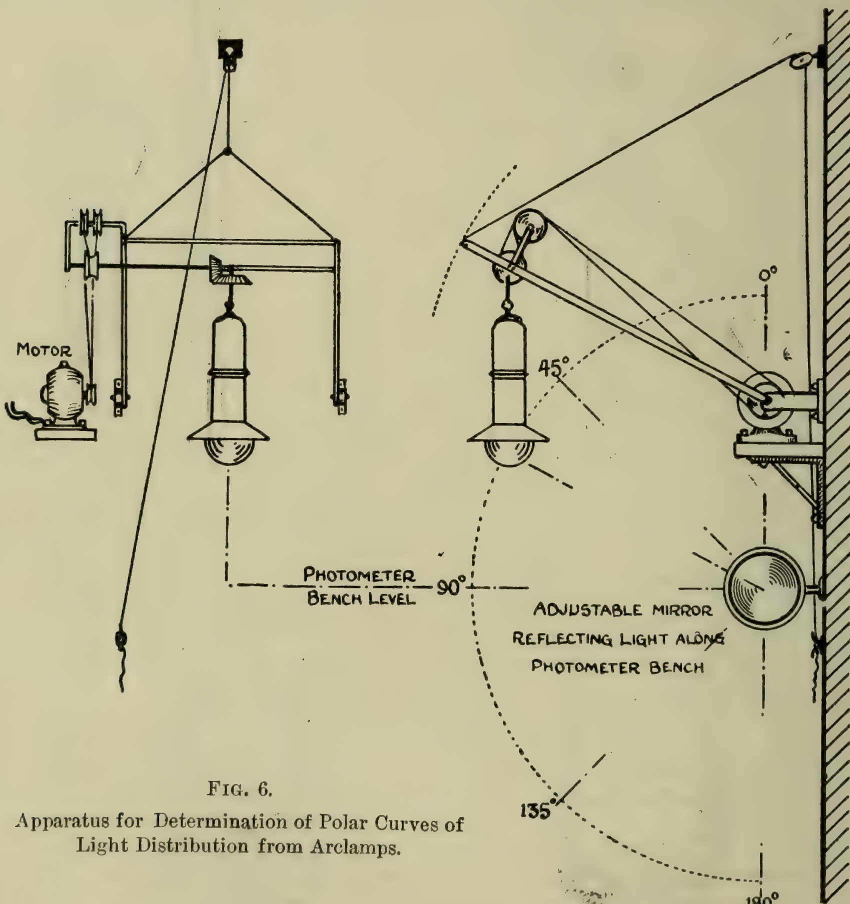


FIG. 6.

Apparatus for Determination of Polar Curves of Light Distribution from Arclamps.

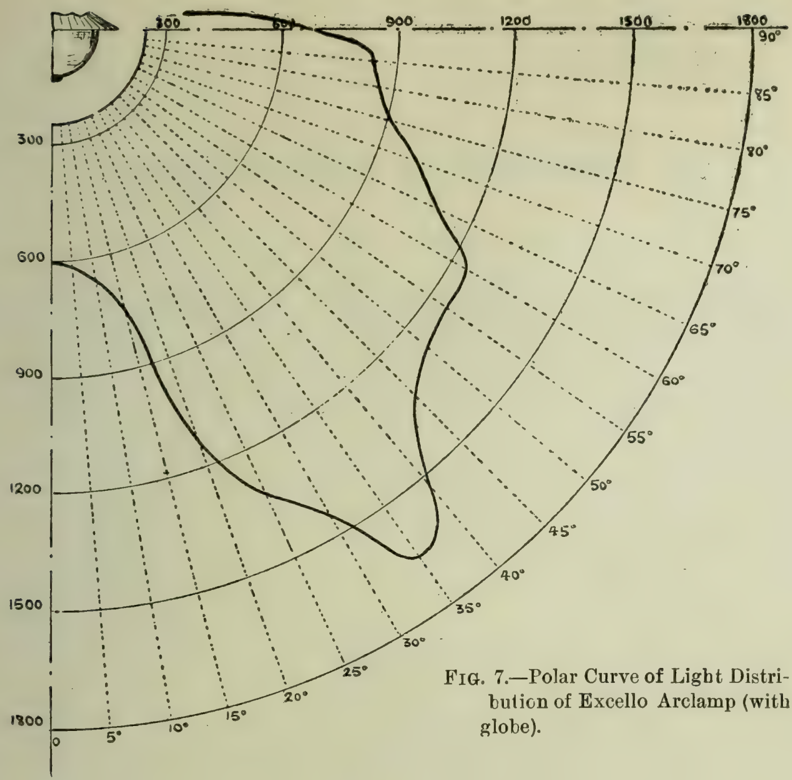
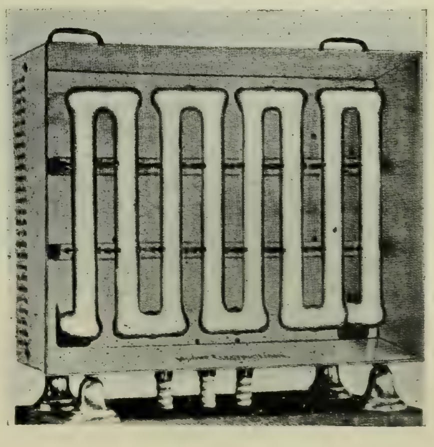


FIG. 7.—Polar Curve of Light Distribution of Excello Arclamp (with globe).

The Moore Light Window.

A new development of the Moore light in the form of small units specially designed for matching colours in textile factories &c., has recently been made. Such units utilize about 17 ft. of coiled tubing $1\frac{3}{4}$ in. in diameter, the tube being filled with carbon dioxide. The area of the "Moore Light Window," as this unit is termed, is about 2 square feet. It consumes 2000 watts, and is preferably run off 220 volts with a frequency of 60.

The advantage claimed for the carbon dioxide tube is that a spectrum closely approaching that of daylight is obtained, and it is stated in *The Illuminating Engineer* of New York that 10,000 factory hands in mills in the New York district were enabled to work regularly by the aid of this light, whereas previously they would have been compelled to be idle on dark days and late in the afternoon.



The Development of Inverted Lighting.

THE introduction of high candle-power metallic filament lamps has led to a considerable development in indirect systems of lighting. The method has long been used in conjunction with arc lamps, but such sources are not always well suited to interior lighting though they have been effectively utilized in very large spaces. Indirect lighting by carbon filament lamps has also been practised, but the loss of light occasioned by the process was often a serious matter, and the sacrifice of efficiency was naturally grudged by the consumer.

But with the introduction of metallic filament lamps the conditions were considerably changed. There was now no difficulty in making lamps of sufficiently high candle-power — indeed, in the case of fairly high voltages, such lamps usually give better results than do small units—and the considerable gain in efficiency rendered the loss of light inevitably entailed by reflection of less consequence. Consequently we find that indirect and semi-indirect lighting is now making its appearance more often, especially in the United States, and in many forms which would probably not have developed had only carbon filament lamps been available.

The advantage of electric glow-lamps in being capable of use in any position naturally rendered them specially convenient for use in an indirect manner. On the other hand, it may be noted that indirect and semi-indirect lighting by gas has also been used effectually; for example, in the lighting of certain schools in Münich. More recently the inverted mantle has been utilized in connexion with indirect fixtures, and an example of this kind of fixture was recently referred to in this journal.* It may also be noted that a recent communication by M. Greyson de Schodt before the Société Technique du Gaz describes the use of inclined burners. If mantles can be successfully burnt in upright, inverted, and inclined positions—and if, in addition, the inclination of a mantle in a fixture can be adjusted at will, as this author has suggested—there seems no reason why gas indirect systems should not be more extensively utilized.

* *Ill. Eng.*, Lond., May, 1910, p. 347.

As regards the merits of indirect lighting in general there has recently been much discussion. Its advocates do not fail to lay stress on the advantage of avoiding any possibility of glare through seeing the naked source of light. On the other hand, some authorities have contended that the mere exposure to the eye of a large light bright surface, such as is produced by inverted methods, is in itself distressing, and to some extent glaring, even though the actual brightness of the surface may be relatively low. It has also been suggested that the absence of shadow and uniformity of illumination associated with some forms of inverted lighting, and the impression of "flatness" to which this gives rise, are not really good for the eye. Violent contrast in light and shade, it is true, are generally considered unsatisfactory. But possibly the eye may also be wearied by continuous exposure to monotonously bright surroundings, and there are some who have suggested that a certain amount of contrast is desirable, so that the eyes may occasionally be rested by transferring the gaze to some surface which is less bright than that previously observed.

However, with the greater use of indirect methods we shall no doubt learn more fully what defects must be avoided. It has been suggested that the method would often be valuable in conjunction with additional local

lighting. No doubt there are many devices which would help to remove the impression of flatness. When only a portion of the ceiling is effectually lighted, it is even possible to produce a pleasing effect of contrast. Such an example is presented by Fig. 1, which is taken from a recent number of *The Illuminating Engineer* of New York. It represents the entrance way to the Capitol, Washington, and we may observe that there is no question here of uniform brightness. The effect is rather of special local illumination and soft shadow.

Fig. 2, referring to the grill room in the Blackstone Hotel, Chicago (*Illum. Eng.* of New York, July, 1910), is also interesting as an example of the use of indirect fixtures with a highly decorative ceiling broken up into separate panels. It may be noted that

FIG. 1.—Entrance Way to Capitol, Washington, U.S.A.

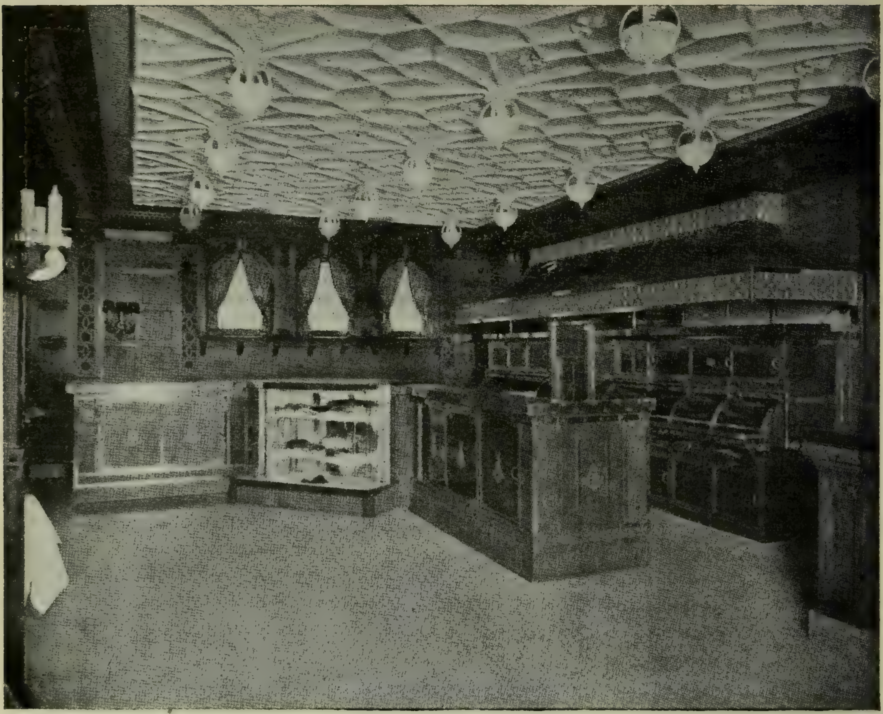


FIG. 2.—Grill Room, Blackstone Hotel, Chicago.

in this case side brackets, with imitation candles, were also used, but for a purely decorative purpose. This seems to illustrate another development in connexion with the indirect system. This method may be employed to supply the necessary illumination, and, in addition, local lights provided, which are not expected to add to the illumination to any very great extent, but only to serve as decorative objects, and remove any impression of "flatness."

It may be noted that in this hotel special care was bestowed on the lighting arrangements, and the president of the Blackstone Co., before deciding on this system, made a tour of many of the chief hotels. He found, however, that the illumination was rarely adequate. On his return he took the matter up with his architects, and also availed himself of the services of expert illuminating engineers. It is stated that this is the first hotel to adopt indirect illumination on a large scale.

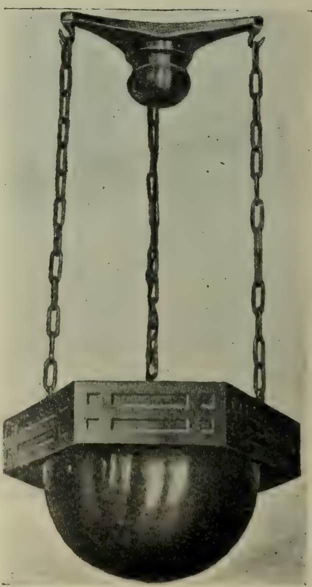


FIG. 3. — Decorative Form of Inverted Fixture.

Short Notes on Illuminating Engineering.

From all Sources.

Criticising the Lighting of a Restaurant.

At a recent meeting of the Illuminating Engineering Society in the United States a somewhat novel departure was made. The members met together to dine at a new restaurant in Chicago, in an informal manner, but with the special object of examining and criticizing the lighting installation.

The discussion was opened by Mr. J. L. Hamilton, the architect of the building, who explained his ideas in arranging the lights of the restaurant. In the informal discussion which afterwards took place the two central lighting fixtures received praise, but the wall brackets were criticized on the ground that they were too low in the range of vision and too plain in style. It was suggested that they might preferably have been placed higher up near the tops of the columns, and that the illumination and the artistic appearance of the room would have been improved had this been done. It was, however, agreed that the lighting of the room served very well to illustrate how an architect could attack the problem of providing efficient illumination, and yet bear in mind the artistic aspects ; still, much had still to be learnt as to the best methods of combining these features.

Floating Electric Signs.

Signs of the Times describes a departure in American advertising methods which would certainly be considered startling in this country. The device consists in displaying large electric signs in the sea, the illuminated devices being placed on floats and anchored opposite well-known seaside resorts.

The Qualities of a Good Salesman.

The essentials for successful salesmen in the gas and electric appliance business are :—

Neat personal appearance ;

Familiarity with the conditions in your district ;

A working knowledge of what you are offering for sale ;

An accommodating spirit ;

Truthful statements ;

Control of temper ;

The exercise of extreme care in the matter of promises ;

Gentlemanly persistence and patience and entire absence of familiarity either in manner or speech.

All of the foregoing, not one of which is either burdensome or unreasonable, are required by the company of its representatives and will be rigidly insisted upon.—K. T. Schick, *Prog Age*, June 1, 1910.

Educating Canvassers in Illuminating Engineering.

We have found that monthly prizes given to the canvassers who turn in the greatest number of sales produce excellent results, creating a spirit of rivalry which is kept up from month to month throughout the year. . . . We also have our illuminating engineer give the canvassers talks on illumination, so as to fit them for better and more intelligent work in the field, for the future of the illuminating business depends on the effective work done by the men. The hours of our canvassers employed in the store work should be from 1 to 9 or 10 o'clock in the evening, as the most effectual work can be done after dusk. I know it would create a better feeling towards

the company when the merchant sees that we are looking after his interests at the time when his lights are burning. —R. R. Young, paper before the National Commercial Gas Association, U.S.A.; *Am. Gas Light Jour.*, June 13, 1910.

A Higher Standard of Illumination Benefits both the Electrical and the Gas Industry.

The leading factor in the development of the use of gas for store lighting is the continuing demand for a higher standard of illumination. The use of the tungsten lamp has stimulated this demand, and so has been beneficial to the gas industry. The future is likely to see a still greater demand for higher illumination, and that relative economy of gas lighting is bound to keep it in control of a very large share of store lighting. The gas company thus sells the article which gives the consumer the most light for his money, and it is for us to use every means in our power in the way of good service, aggressive activity, and constant watchfulness, so that we can make still further advances in our business.—R. R. Young, paper before the National Commercial Gas Association, U.S.A., *Am. Gas Light Jour.*, June 13, 1910.

Data Wanted on the Best Positions of Street Lamps.

There is one consideration of vital importance in regard to the lighting of streets and open places which rarely receives the attention it deserves from municipal authorities, and that is the proper placing of the lamps.....

Sound practice in this matter seems to be a thing "overheard" in the conflicts of lights and systems rather than reduced to a recognized order and method; with the result that, while good work is done occasionally, and sporadically, awful examples of "how not to do it" are quite as likely to crop up where the decision happens to rest with individuals who have not given the matter attention, and are incapable of doing so.—*The Gas World*, July 2nd, 1910.

The Avoidance of Glare.

Apropos of the question of light rays in their effect on the retina, an interesting commentary was afforded at a recent public wrestling match in Chicago, at which mercury vapour lamps of high intensity were used for the purpose of enabling cinematograph pictures to be taken of the exhibition. The almost blinding light proved to be very trying to the eyes, and not a few people complained of eye fatigue in consequence. A few spectators, however, who had had the forethought to provide themselves with eye-shades suffered no ill effects to their eyes. This is not recorded as a reflection on the mercury vapour lamp, which has proved its extreme value for many purposes, but only to show the wisdom of avoiding a long-continued glare on the eyes which will prove injurious no matter what may be the source of illumination.

It is sincerely to be hoped that the study of illumination will soon be placed on a sounder basis than it is at present, and that the first step, which might well be undertaken by a national or international commission, will be the exact definition and standardization of an appropriate phraseology.—*The Electrical Review* (New York), June 11, 1910.

Shadow Needed in Window Lighting.

As to window lighting. I do not believe there is any question that this can best be taken care of with small units in the front of the window. This "shadowless" window lighting is an ideal which has never been realized, and you would not want it if you could get it. You must have shadows; we get shadows under natural conditions of daylight, and we require shadows for the proper comprehension of proportion, size, and detail.

—N. McBeth, *Am. Gas Light Jour.*, June 13.

Co-operative Lighting.

A CORRESPONDENT to a recent number of *The Electrical Review* mentions what he regards as an interesting example of co-operation in lighting between two customers. The pressure of supply in the locality he refers to is 240 volts, and two adjoining shops propose to run wires from one consumer's premises and meter along the entire frontage, so as to run four arc-lamps in series.

It would be interesting to know how far this principle of co-operation has been carried in other cases. A much more radical departure is, of course, the plan followed by all the shop-keepers in a street in some towns in the United States. In these cases the merchants clubbed together to supplement the public lighting of the streets by private lamps, recognizing that the expense involved was fully compensated for by the increased traffic and trade due to the improved illumination.

Co-operation between the Gas and Electrical Industries.

COMMENTING on this subject *The Progressive Age* remarks :—

"The industries are not so far apart as some think. In 1907 there were 329 electric stations which operated gas plants and probably as many gas enterprises which operated or owned electric plants ; so that probably two-thirds of the gas industry are more or less interested in electric plants also. The tendency to merge the two industries continues, encouraged by the growing belief among both producers and consumers that competition of that kind is not a good thing."

Wanted—An Impartial Jury.

"FIGURES canot lie" (*sic*). What is the poor man in the street to believe ? We have a theory that if he reads such things at all he is rather losing his temper over all these divergencies between the electrical and gas champions. In the beginning he had the haziest of notions as to which one was the truth-teller and whether the truth lay half-way between ; but now that he has so many columns on the subject put before him every morning, we hope that some impartial body of citizens, bent upon hunting down the truth, will sooner or later equip two model houses (not laboratories) with the rival illuminants in strictly working conditions and publish the annual results. We cannot organize it, the gas people cannot organize it, but in the interests of bewildered humanity something of the kind ought to be done forthwith.—From *The Electrical Times*, July 21st.

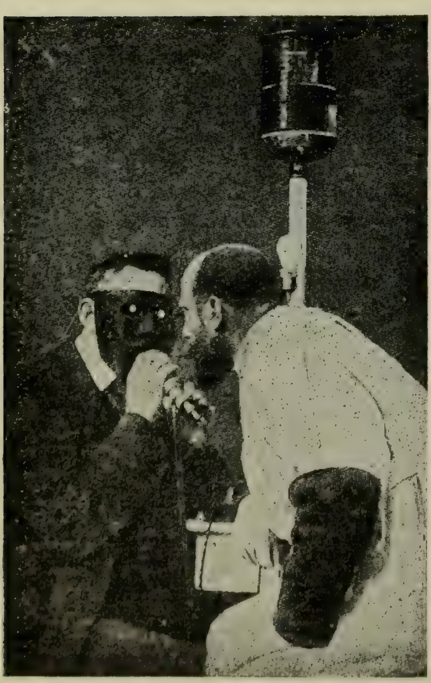
The Need for the Illuminating Engineer.

It is well known to every illuminating engineer that the men actually engaged in the business of electric lighting are, generally speaking, as indifferent to the primary rules of effective and economical illumination as the people who use the light. There is no need to draw up a formidable code of rules and regulations, but there is a great need for the propagation of a few elementary truths about the proper arrangement and shading of light sources in order to secure adequate illumination without glare and without loss of candle-power. —*Electrical Investments*, July 6, 1910.

Renewing Tungsten Lamps.

An interesting new process is referred to in a recent number of *The Electrical Times* (June 23rd), namely, the renewing of old metallic filament lamps. Various attempts have been made in the past to renew carbon filament lamps, the filaments of which only had given way, leaving the rest of the lamp intact. But carbon lamps could be obtained so cheaply, and the cost of renewal was therefore so small, that it was difficult to make the process a success. But at the present high cost of metallic filament lamps there is a much greater margin, though the technical difficulties are considerable.

It is stated, however, that such a process is actually in operation in the United States. According to this method a small hole a quarter of an inch in diameter is made in the pip end of the lamp, and a special tool is inserted to withdraw the broken ends of the filament. Should the lamp have blackened, the deposit is removed chemically before the filament is treated. Subsequently a new filament is attached to the supports with tungsten paste, hydrogen is pumped into the bulb, and the ends are welded on by starting a small arc. Afterwards the bulb is exhausted in the ordinary way. It is stated that the cost of renewal will not exceed 6*d*. per lamp, and will be the the same irrespective of the candle-power and voltage of the lamp treated.



Illuminating the Eyes through the Mouth.

This illustration does not show a wild man eating electric light fixtures, but an ordinary man who is having his eyes illuminated by an electric light bulb placed within his mouth. The apparatus is known as the ophthalmo-diaphanoscope, and it is used to examine the back of the human eye.

Essentially, the apparatus consists of a portable cylindrical electric lamp, with self-contained tube, providing for water-cooling. The patient places the bulb in the mouth as far back as possible and against the upper wall of the buccal cavity. Viewing the pupil of the eye from the front, the highly illuminated retina is brought before the surgeon, who is able thus to diagnose the appearance of the membranes and pathological conditions at the back of the eye.

The mask which lends such a ferocious aspect to the face is worn so that the impression given by the central field of illumination may not be impaired.—(*Popular Mechanics*).

The Public's Complaints.

MR. CHAS. L. BARRET, in a recent paper before the Pacific Coast Gas Association, at San Francisco, gives an interesting account of his methods of pacifying consumers, whose occasional ungrounded suspicions against the lighting company require tactful handling.

For instance, we are told that in the winter of 1908 a public clamour was raised against what was thought to be the poor quality of gas, low pressure, and exorbitant charges of the San Francisco Company. Eventually a widely advertised public hearing before the Artificial Lights Committee of the City was held, when, of the 80,000 consumers of the Company only 16 appeared to complain. However it is stated that the agitation indirectly achieved good, since it led to joint investigation and report by a body of gas and electrical experts by the "supervisors" of the city. This report elucidated many misconceptions on the part of the public, and its subsequent circulation did much to stimulate confidence in the lighting company.

The paper contains a number of amusing letters from consumers, the following being too good to be lost :—

" S. F. Gas and Elec. Co.—Gentlemen,—I wish you would send a gas leak at your meter.—Respectfully,—Mrs. P. C."

From a Chinaman : " Please you call, fix meter, heap stink."

S. F. Gas Co.—" My gas meter is out of order ; also my neighbour, Mr. Schmidt. Will you please send somebody to fix them ? "

From another Chinaman : "We have been burning your gas for so many years and that usually to pay the bill from \$3 to \$5 a month with no excessive ! However the bill claims so much in the future two months. It is hardly to satisfactory. We will mail these receipt to you kindly compare it at once whether its reighteous. Answer. Respectfully yours, ——."

On Educating the Customer.

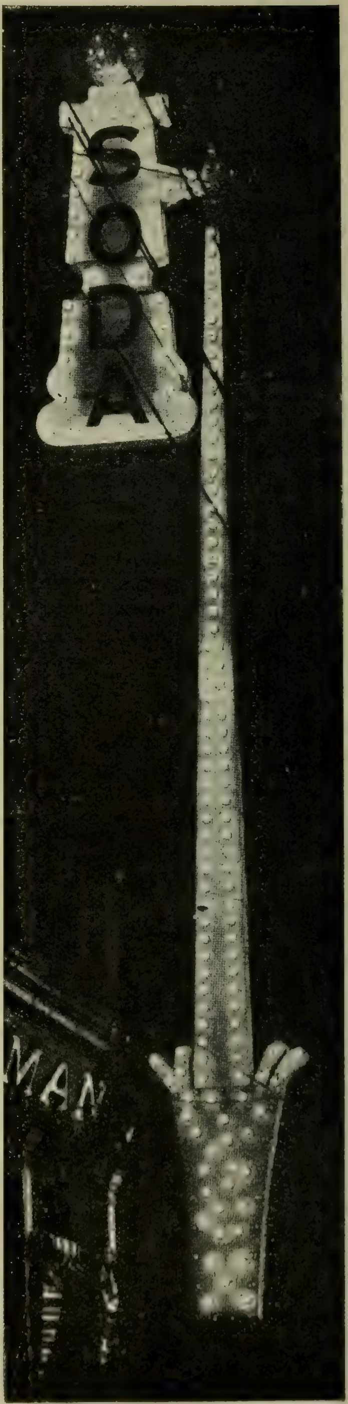
IN his recent Inaugural Address before the Institution of Electrical Engineers, Dr. Gisbert Kapp, the President, drew attention to one matter of considerable interest to all engaged in the sale of engineering appliances and especially applicable to those engaged in illuminating engineering.

How was it, asked Dr. Kapp, that electrical engineering was not as prosperous as it might be ? There was progress, but it was not fast enough, and to accelerate it they must educate the potential users of electrical plant.

On the Continent every large electrical engineering firm had a literary department whose business it was to educate possible customers. No sooner was a cotton mill electrically equipped than well-written, well-printed, and beautifully illustrated leaflets were sent out to possible clients.

This should be borne in mind by those engaged in the sale of light or lamps. Progress in all systems of illumination is so rapid that even an expert finds it hard to keep in touch with the most recent developments. How much more so the general public !

Novel Electrical Signs.



The illustration of the sign accompanying this note is taken from *Signs of the Times* for August of this year.

At the present time, when illuminated signs find such favour as a means of advertising, novel devices are in this direction of rather special interest. This illuminated sign is intended to represent a soda water bottle emptying its contents into the tumbler below. It is further stated that by an ingenious flashing device operating various different coloured lamps a very vivid impression that the liquid is pouring into the glass below, and that a succession of bubbles is rising to the surface, is produced. It is stated that this sign was originally put up outside a chemist's shop in Knoxville, Tenn., in the United States, and the Greenwood Advertising Co., by whom it was constructed, have made six duplicates of the design for the benefit of southern American cities.

Another very interesting sign in New York, bearing on a similar subject, is described in a recent number of the *Electrical World* (Sept. 2nd, 1909). It consists of a gigantic ginger ale bottle, outlined in tungsten lamps, and evidently in lively effervescence. The mechanism of the sign causes it to make three distinct flashes. The first simply shows the bottle and the lettering describing it, the second shows the effect of the cork being "popped" and the contents of the bottle shooting into the air; the third shows the liberated liquid foaming down the neck of the bottle. The lower portion of the sign is stated to be 15 ft. high and 45 ft. long, and thus makes an effective advertisement by day as well as by night. Over 3,000 lamps are stated to be made use of in this sign.

A Chauffeur's Head Lamp.

A recent number of *Popular Mechanics* refers to the development in the United States of a small electric "head-lamp" for the use of the chauffeur. When the latter is obliged to creep beneath the car and to examine machinery in out-of-the-way corners, his hands are usually occupied and he cannot conveniently carry a lamp. This difficulty is met by the use of a small electric glowlamp fitted with a reflector which is strapped on to the forehead, and is fed from the accumulators on the car. In this way light is thrown in any direction in which the eyes are directed, and there is no possibility of glare.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

Incandescent Oil Table Lamps and Pendants.

THE arrival of the inverted mantle has been of considerable service to oil-lighting, and in country districts where gas and electricity are not available the more powerful light yielded by the oil-fed inverted mantle is particularly serviceable.

The accompanying illustrations refer to two "Blanchard" lamps of this kind constructed by the **Gas Economising and mpro ved Light Syndicate, Ltd.** (151, Farringdon Road, London, E.C.).

FIG. 1.

Fig. 1 represents the Blanchard Safety Table Lamp, burning paraffin with an inverted mantle. The lamp is quite portable, and the mantle, completely enclosed, is stated to give an excellent light, providing 1,000 candle-power-hours at a cost of less than a penny. In addition the lamp is claimed to be exceptionally safe and easy to manage, and is not readily affected by its being inadvertently tilted or shaken.

Fig. 2 shows a hanging lamp of the same kind. This, too, can be easily removed and installed in different positions, being only dependent on the fuel in the receptacle above the lamp. These lamps can also be very easily and conveniently fitted with silk shades above the reflector, fringes of beads, &c., for dining and drawing-rooms, &c.

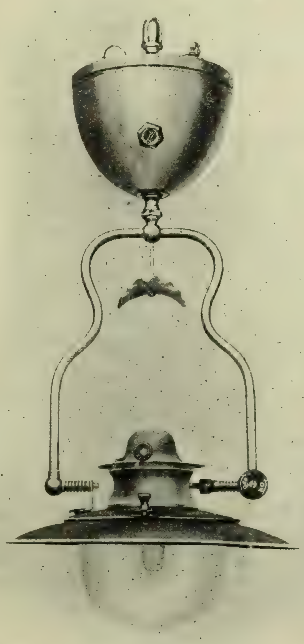


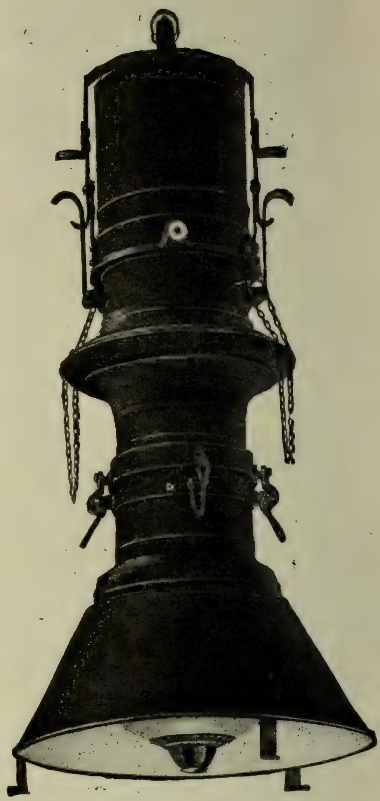
FIG. 2.

WE are informed that the London & North-Western Railway have accepted the tender of **William Geipel & Co.**, Vulcan Works, St. Thomas Street, London, S.E., for the supply of Henrion Arc Lamp carbons during the year ending June 30th, 1911, for the whole of the company's requirements, the total annual consumption amounting to 1,373,000 carbons.

The above is a renewal of last year's contract.

Excello Flame Arc-lamps.

From the **Union Electric Co. Ltd.** (Park Street, Southwark, E.C.), we receive copies of the most recently issued lists relating to Excello arc-lamps. Particulars are again given of the deposit-free covers used with these lamps ; special reflectors for docklighting and shop illumination and inverted designs are also shown. Attention is drawn to the self-contained automatic switches and improved compensating devices used with these lamps. From the same company we also receive particulars of the hand-fed "Kino" cinematograph projection lamp using one horizontal and one inclined carbon, and of the "Fortiter" three-phase motor starters.



Excello Dockyard Lamp.

Another Osram Innovation.

Certain Osram Lamps which have been in use for street lighting in various parts of the country are said to have lasted an exceedingly long time. It is, however, interesting to record that occasionally the metal caps have been found to become actually eaten away, through prolonged exposure to the elements, before the filaments had failed.

We now learn from the manufacturers that on this account they have decided in future to supply high Candle-Power Osram Lamps with practically indestructible plated copper caps instead of brass as heretofore. It is, indeed, remarkable that the filament should outlast the cap in the manner recorded, but we understand that such has proved to be the case on many recent occasions.

Messrs. Siemens Lamp Works Annual Outing.

On Saturday last over 500 employees of Messrs. Siemens Bros. visited Brighton, leaving London Bridge at 7 o'clock by special train, for their second annual outing. Luncheon was provided by the company in the Hall of the Aquarium at 12-30, followed by a musical programme of an attractive character, and the rest of the day was of a most enjoyable character. A vote of thanks to the committee and Mr. Hicks, the Secretary, for the general success of the outing, was proposed by Mr. Holmes and carried with acclamation.

New Type of Tantalum Lamp.

We are informed that **Messrs. Siemens Bros. Dynamo Works, Ltd.** (Tyssen Street, Dalston, London, N.E.), are now placing on the market a new type of tantalum lamp in a tubular bulb, 100-130 volts, 25 c.-p., for single or series burning, at a list price of 3*s*., subject to the usual terms and discount. The overall length is 5¼ inches and the diameter 1½ inches.

It is stated that these lamps will burn at 1·7 watts per c.-p., and will be serviceable alike for direct and alternating currents. It is anticipated that they will be of considerable value for Strip Light Reflectors for Shop Windows.

REVIEWS OF BOOKS.

Illumination and Photometry.

By W. E. Wickenden, Asst. Professor of Electrical Engineering, Massachusetts Institute of Technology, U.S.A.

(*The Hill Publishing Co., Ltd.*, 6, *Bouverie Street, London, E.C.*)

The publication of such books as this dealing with illumination and photometry illustrates the growing recognition that this subject deserves special treatment. The author explains that this work is intended to serve as a text-book on the subject and as a help to the student anxious to gain an up-to-date general knowledge of recent developments, rather than for the expert in illuminating engineering.

Chapters I. and II. deal with fundamental conceptions regarding the production and propagation of light, the reflecting powers of different surfaces, &c., and a table of luminous efficiencies, due to Lux, is presented. Definitions are also given of the chief terms and quantities used in illuminating engineering, luminous intensity, luminous flux, illumination, &c. The author uses the term "luminosity" to express what is perhaps preferably termed "surface brightness." A table is given connecting the values of the chief light standards, and reference is made to the decision arrived at between England, France, and the United States last year on the subject of the international candle. In a future edition the author might profitably include at this point a table connecting the various units of intensity of illumination, similar to that recently published by Dr. B. Monasch in this journal.*

Chapter III. contains a brief but up-to-date description of the chief standards of light.

Chapter IV. contains a summary of hygienic points, and concludes with a series of succinct recommendations. The importance of avoiding flickering, unsteady lights, or anything in the nature of glare, is insisted upon, and it is recommended that sources, the intrinsic brilliancy of which exceeds 5 c.-p. per square inch, should preferably not be used in interiors, and that all lights sending rays to the eye at angles of more than 60 degrees below the horizontal should be effectively screened.

Chapter V. refers to the calculation of photometrical quantities, including mean spherical candle-power, and an account is given of the methods of Kenelly, Wohlauer, and others. Chapters VI. and VII. deal with photometers. A description is given of several of the best-known instruments, such as the Lummer-Brodhun, and several flicker types are also described. Some account is also given of illumination photometers. In a future edition this section might profitably be extended to include some of the most recent European designs of these instruments.

Several chapters are devoted to electric and gas-lighting. The former section is dealt with in a comprehensive and up-to-date manner. In the section of gas-lighting we should certainly like to have seen more mention of the high pressure installations which form an important feature of street lighting in Europe. We might also suggest that the study and measurement of daylight illumination might receive a little more attention.

The remaining portions of the book deal in a general manner with the calculation of illumination, and some sound advice is given regarding the planning of installations.

To deal with all the matters included under the heading of 'Illumination and Photometry' in a work of about 200 pages, even in a cursory manner, is naturally no easy task, and while we have suggested a few respects in which additions to this work might profitably be made in a future edition, without unduly swelling its size, we recognize that Professor Wickenden has been able to cover a very wide range of subjects in the space at his disposal. We do not doubt but that the work will be appreciated by students and others wishing to make a rapid survey of the subject. The explanations seem lucid, and the tables and diagrams are clear and satisfactory.

* *Illum. Eng.*, Lond., Vol. II., 1908, p. 742.

The Manufacture of Incandescent Mantles.

(*Die Fabrikation der Glühkorper für Gasglühlicht.* By Dr. C. R. Böhm, *Halle. Germany,* 1910, *Verlag von Wilh. Knapp.*)

This work contains about 450 pages. It is intended as a thoroughly practical treatise, enabling those engaged in the manufacture of incandescent mantles to gain a comprehensive insight into the technical development of the mantle and the conditions which govern the industry at the present time. The author's intentions in this respect may be said to have been well fulfilled. He has been very successful in reviewing the immense number of patents of different countries bearing on this subject, and especially in presenting the somewhat tedious details, of which such patents frequently consist, in an interesting and attractive form. It may be added that the work contains in all 431 illustrations and 8 tables.

Among the many sections of the subject dealt with may be mentioned:—

The raw materials, their applications, and the most important processes connected with the rare earths; the manufacture of mantles, including an exact description of the various stages and processes involved; the burning off process, and the mechanical devices entailed in the process of manufacture; the most important chemical and physical researches, and the laboratory study of the mantle.

The work concludes with a comprehensive subject and authors' index bearing upon patents on this subject, and can be recommended to all who are concerned with the mantle industry.

W. V.

Colour Blindness and Colour Perception.

By F. W. Edridge Green, M.D., F.R.C.S.

(*Messrs. Kegan Paul, Trench, Trübner & Co., Ltd., Dryden House,* 43, *Gerrard Street, Soho, London, W.*)

In the preface to the first edition of this work the author explains that he has verified his theory of colour perception by tests of 116 colour-blind persons of various kinds; many of these cases are described in this book. We have heard a great deal about colour-blindness recently and those who have been somewhat bewildered by the conflicting views of different authorities will find Dr. Edridge Green's book of considerable interest. With one of his statements in the preface to the second edition readers of this journal will doubtless find themselves in cordial agreement—"What we want to get at is the truth. Never mind who finds it out."

In the opening chapters the author explains his theory of colour vision, some reference to which has recently been made in this journal,* and also gives a short summary of other well-known theories. In passing it is interesting to note that Dalton discovered that he was colour-blind by observing that a variety of geranium, which to other people appeared pink both by day and artificial light, appeared to him blue in the daytime while by candle light there was no trace of this colour. Thus at the outset we have an illustration of the value of a comparative test by daylight and artificial light as a means of detecting colour blindness.

Dr. Edridge Green proceeds to analyse the various conditions which may result in peculiarities of colour vision. He regards the series of six distinct colours which the normal person can detect as a "psycho-physical" series. The ability to analyse and discriminate between the different units in the series is located in a special centre of perception in the brain. There are many interesting and curious facts mentioned by the author to illustrate this suggestion. For example, that colour blindness accompanies certain forms of insanity, and that it can be produced hypnotically. But the sense-organ, the nerves, and the memory centre also play their parts in producing the final impression, and an interruption at any point in this chain may prejudice the result.

Colour blind subjects fall into 5 main classes. There are people who can

* *Illum. Eng.*, Lond., Vol. II., 1909, pp. 210, 741.

only distinguish five, four, three, two, or even one unit. It is further suggested that in past ages the sense of light was developed before the power of perceiving colour, and that the latter sense passed through the various stages of evolution until the present conditions were reached. Even now we have traces of a further development, since a few specially gifted people are able to distinguish seven units. There may also be diminished sensitiveness at either end of the spectrum, leading to a loss both in colour-perception and in luminosity. Another singular fact, mentioned elsewhere in this book, is that the class of people among whom colour-blindness appears to be most prevalent is the musical profession!

Chapter V. is devoted to a full explanation of the retina, and the part played by the visual purple. An array of facts is presented in support of the idea that this substance is intimately connected with vision. For example, it is bleached most readily by the part of the spectrum to which the eye is believed to be most sensitive, the yellow-green. The author holds the view that the "rods" on the retina are concerned only with the distribution of visual purple, and not with the conveyance of light impulse to the brain. Information can also be gained from the study of "after-images," and their complexity should not be forgotten by those who have suggested that the examination of these images might constitute a test of "glare."

In the concluding part of the book very detailed instructions for methods of testing are given. One searching test is that in which the person studied is asked to select pigments and imitate, in a prescribed outline, the colours of a picture presented to him. Other tests are based on the selection of apparently monochromatic patches in the spectroscope, and on general questioning, classification of colours, observation of coloured objects at a distance, &c.—all of which, it is suggested, may yield valuable confirmatory evidence. Particulars are given of the tests to which railwaymen and seamen are at present subjected, and the author insists on the vital importance to the public of more complete methods of ascertaining the state of vision of those following these two occupations.

In support of his contentions that the present methods of testing are inadequate the author gives a number of striking facts. For example he states that, according to the Board of Trade Report for last year, over 53 per cent of those who were rejected for colour-blindness by the "wool test" were subsequently found to have normal vision. He also remarks that he has personal knowledge of a number of pilots and naval officers who are now engaged in their employment but who are more or less colour-blind.

It will be generally admitted that, both for the sake of those whose livelihood depends on their being believed to possess correct colour perception, and also for the benefit of the general public whose safety may be imperilled by their unfitness in this respect, tests of colour-blindness should be of a searching and reliable character. Those concerned with these questions will read Dr. Edridge Green's suggestive and instructive book with interest. Many of the matters discussed have also an indirect bearing on illuminating engineering.

Tables for Illuminating Engineers.

(*Rechentafeln für Beleuchtungstechniker.* By Dr. W. Bertelsmann. *Ferdinand Enke, Stuttgart,* 1910, Mks. 2.60.)

This little work, devoted to tables used in calculating candle-power and illumination, is published at an opportune moment, when the value of exact knowledge of conditions of illumination is better appreciated than in the past. The author, in his preface to the work, truly remarks that photometry has emerged from the physical laboratory and become a recognized industrial process.

The first chapter contains definitions and particulars of the symbols of the International Photometrical Commission for the chief photometrical quantities. A table of conversion for units of light is also given. To this might profitably be added a table of the units of intensity of illumination in use in different countries.

The greater part of the book is filled by a series of tables enabling the candle-power of the source tested to be rapidly noted for positions of the photometer on the photometric bench. Data for the calculation of mean spherical candle-power from polar curves of light distribution are also given. At the end of the book is a miscellaneous series of tables containing particulars of performances of different kinds of lamps, the absorption of globes, &c., and other data of interest to the illuminating engineer. The book should be found of considerable service by those constantly engaged in the calculation of photometric quantities. Its value to those in this country would, of course, be enhanced by translation.

Gas Installations and Gas-Fitting.

(*Der Gasrohrleger und Gaseinrichter.* By F. Kuckuk. *R. Oldenbourg, Munich and Berlin, Second Edition,* 1909.)

In his preface to the first edition of this work the author explained that although there were a number of works in the German language dealing with various sections of gasfitting, there was no general work dealing with this subject in a wide and adequate manner. The second edition has been rendered necessary by the rapid strides in the use of gas during the past few years, especially in the direction of heating and power.

The book contains upwards of 300 pages and covers a considerable amount of ground. The first chapter briefly discusses the generation of different qualities of illuminating gas. Subsequently detailed instructions are given regarding gas distribution and the laying of piping both in the streets and in private dwellings. The development of the upright and inverted burner, high pressure lighting, automatic control of street lamps, lanterns, and other matters connected with gas lighting are next dealt with, and we are pleased to see that the author, though dealing in detail with the technicalities of the distribution of gas, also finds space to cover the field of lighting developments. However, while recognizing that the scope of the work hardly enables very much space to be devoted to the illuminating engineering aspects of gas lighting, we should still have liked to see a little more attention paid to the use and measurement of light as well as its production.

The remainder of the book is given up to heating and cooking apparatus, and to gas engines and power. This work is of a practical character and contains an abundance of illustrations. It will doubtless commend itself to many of those concerned with the distribution and utilization of gas.

Some Publications Received.*

Remané, H.....Die Osramlampe und Ihre Anwendungsgebiete (Reprint from the Bulletin of the Swiss Institution of Electrical Engineeers. Zürich, 1910).

F. Schanz and K. Stockhausen....Zur Atologie des Glasmacherstars....Blendung ihre Ursachen und Wirkung Weiteres über Blendung....Schutz der Augen gegen die kurzwelliger Strahlen....Schutzgläser gegen die Wirkung kurzwelliger Lichstrahlen auf das Auge.

The above constitutes a series of reprints of various papers setting forth the views of these two investigators on the nature of glare and the effects of ultra-violet light on the eye. Their contentions are illustrated by numerous excellent spectro-photographs showing the nature of the absorption exercised by the eye and by various kinds of glass towards ultra-violet rays.

Journal of the Franklin Institute, June and July 1910.

These numbers contain several items dealing with aspects of illumination. Dr. E. P. Hyde concludes his paper on "The Physical Production of Light," and a synopsis is given of a popular lecture entitled "Modern Methods of Lighting" by R. H. Bradbury.

Among other publications we have also to acknowledge the receipt of:—*The Journals of the British and American Institutions of Electrical Engineers, The American Chemical Journal, The Journal of the Royal Society of Arts,* &c.

* To some of these publications we hope to refer in greater detail shortly.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

MENTION should first be made of the recently issued Report of H.M. Inspector of FACTORIES, which devotes special attention to the subject of illumination. However, this has been noticed elsewhere in this number. Another recent paper, read before the Société d'Ophthalmologie Francaise, which appears to deal somewhat exhaustively with the same matter, and also with the hygienic aspects of lighting generally, is that of **M. Gariel**; this is abstracted in a recent number of the *Revue Électrique.* The paper refers in some detail to the physiological effects of non-luminous energy in the spectra of artificial illuminants, and regards both the ultraviolet and infra-red portions as injurious. In this connexion the author quotes experiments on bacteria and frogs which seem to be in agreement with the suggestion that such rays may have a destructive effect when present in excess. In conclusion a series of general recommendations are given, including the suggestion that in work-places a minimum illumination of 15 lux should be provided. The paper also touches on colour-photometry, acuteness of vision, and other matters. Yet another article dealing generally with FACTORY LIGHTING is published in *L'Electricien* (July 2).

The Illuminating Engineer of New York for July contains a series of readable articles. One of these consists in an illustrated discussion of the ILLUMINATION OF HOSPITALS. It is pointed out that the fundamental rules affecting the correct placing of light sources are very often transgressed. Other articles in the same journal deal with examples of INDIRECT LIGHTING at the Capitol and elsewhere. In these cases high candle-power tungsten lamps were employed, and the method of indirect lighting seems to have been discreetly used. An example of this kind at the Blackstone Hotel, Chicago, is of special interest on account of the decorative ceiling employed.

A communication from **J. Benard** to the Societé des Ingenieurs Civils de France deal' with ELECTRIC SEARCHLIGHTS, &C., FOR LIGHTHOUSES, and the same subject has also been dealt with somewhat exhaustively by **M. Bochet** in a paper now published in the *Bulletin* of the Société Internationale des Electriciens for May. In this latter article particulars are given of various optical systems, and the merits of metallic mirrors and lens arrangements are discussed. A description is also given of group-flashing devices. In conclusion the author shows an illustration of a white house completely illuminated by night by the aid of a military searchlight of this kind. It is rather interesting to notice that this last method is again described in a recent number of the *A. E. G. Zeitschrift,* in which the merits of illuminating the exteriors of buildings, in preference to outlining their architectural features in glow lamps, is dwelt upon.

A series of tests recently carried out by **C. F. Harding** and **A. N. Topping** on LOCOMOTIVE HEADLIGHTS were described in a recent paper at the Convention of the American Institution of Electrical Engineers. One point examined in some detail was the effect of approaching locomotive headlights on the vision of drivers. It was shown that the existing powerful headlights might easily lead to the mistaking of signals, and it was also found that a body sufficiently bulky to wreck a train if placed upon the rails might not be seen in time for the engine to pull up. The rest of this paper is concerned with detailed photometric tests of different kinds of lights.

A series of interesting points in connexion with lighting are discussed in recent numbers of *The American Gaslight Journal.* One matter which may arouse no little contention shortly is the practice of using FLOATING ILLUMINATED SIGNS outside watering places for the sake of advertisement. Other articles in this journal deal with the use of powerful light high up on towers for advertisement purposes, and the use of illuminated hands for notices, signs, &c.

Among papers and articles dealing with photometrical subjects special mention should be made of that by **E. B. Rosa** and **G. W. Middlekauf** on CARBON INCANDESCENT LAMPS AS PHOTOMETRIC STANDARDS. The authors consider that by using a large number of such lamps the unity of light could be

kept constant for a large number of years. Directions for the "aging" of these lamps are given. The authors lay stress on the value of a double test, with two potentiometers, of both the current and voltage of a lamp. By this means a gradual increase in current can sometimes be detected in the first ten minutes or so that a lamp burns on test, and this furnishes a quick and certain indication that a lamp has not been properly aged.

M. Alimot (*L'Electricien*, July 2) describes a form of PORTABLE PHOTOMETER and wattmeter for testing glow lamps.

W. C. Philpott (*Am. Gaslight Journal*, June 27; *Prog. Age*, July 1) contributes a general paper on photometry, particularly as regards gas lamps. He describes the use of the Flicker photometer, and gives some figures for the polar curves of light distribution from different types of incandescent mantles.

Among articles of a more scientific and abstruse character we may notice the interesting work of **C. A. Pierce** (*Phys. Review*, June) on THERMO-LUMINSCENCE. He describes experiments on the distribution of energy in the spectrum of Sidot blend; this was determined by studying the density in different regions of photographs of the spectrum of this light. It is interesting to observe that the maximum appeared to lie in the visible spectrum, and that the shape of the curve, like that of the radiation from the firefly and other phosphorescent objects, seemed to be of a kind favourable to efficient light production.

ELECTRIC LIGHTING.

The metallic filament situation still receives attention, and several authors in the United States put forward suggested rating systems based on the area illuminated under specified conditions. Here we see the idea of CHARGING ON THE BASIS OF ILLUMINATION PROVIDED gaining ground. This point is also dealt with in the editorial notes in a recent number of *The Electrical World.*

An interesting article by **W. H. Miller** (*Elec. World*, N.Y., July 7) deals with the TUNGSTEN LAMP SITUATION IN FRANCE. His experiences of the durability of the tungsten lamp in that country seem very favourable, and he adds that scarcely any carbon lamps are now used. In the United States the experience has frequently been that lamps become more brittle with use, but in France the durability of the lamps improves after they have been in use a short time.

De Kermode (*L'Electrician*, June 4) describes the Weissman system of lighting by means of GROUPS OF LOW VOLTAGE LAMPS IN SERIES-PARALLEL. By using a bank of lamps like this the effect of a lamp failing is comparatively small, since the illumination from the remainder continues. Lamps of 14 volts and 1 c.-p. seem to be considered most satisfactory for grouping on 100 volts. Such lamps are also exceedingly strong, and are credited with a life of 200 hours or more.

Among articles we may note that of **L. Crouch** (*Elec. Rev.*, July 15, 22) on the MERCURY VAPOUR LAMP. The author gives full particulars of cost, efficiency, intrinsic brilliancy, colour, &c., and discusses the distribution of illumination from the sources at a given height. A summary of RECENT DEVELOPMENTS IN ARC-LAMPS is also published in the *Revue Électrique* (June 15). The author refers to the most recent types of Beck lamps, and describes their simple mechanism and the method of using lengths of wire in glass tubes as a series resistance. He also describes the dioptric globes for use with flame arcs and the Hrabowski flame arc-lamp reflector.

Among more purely scientific articles we may note that of **G. Leimbach** (*Zeitschr.*) *f. Wissentschaftliche Photographie, &c.*, July), which deals in a comprehensive manner with the radiation of different forms of electric glowlamps. The author gives polar curves of light distribution in each case and estimates the probable value of the radiant efficiency.

GAS, OIL, AND ACETYLENE LIGHTING, &c.

One important event during the last month has been the finding of the Committee appointed to consider the scheme for a NEW STANDARD BURNER for common use in Great Britain. The report has been favourable, but there seems to be still some opposition. The question of TESTING CALORIFIC VALUE still receives attention, and the report of a recent committee of the American Gas Institute on this point has recently been published. This contains a considerable amount of information, including a comparison of gas used for heating and incandescent mantles, and for flat flame burners, in 1886 and 1910.

Reference may also be made to several interesting historical articles. A contribution to the *Journal of Gas Lighting* traces the growth of system of payment from the early years, when proper methods of measuring were not available. A series of articles in the *Zeitschrift für Beleuchtungswesen* is to deal with the HISTORY OF GAS LIGHTING in various towns in Germany; the first article, just

published, deals with the town of Münich.

Among recent technical developments mention should be made of that described in a paper by **Greyson de Schodt** before the *Société Tech. du Gaz,* namely, the use of incandescent mantles in an inclined position. By this means a more favourable distribution of light can be secured, and the angle of inclination can be varied to suit the local requirements. Sometimes several such mantles are grouped in one lantern.

Buhe deals with the AUTOMATIC DISTANCE CONTROL OF STREET-LIGHTS. He is inclined to suggest that the experiences of Göhrum and Dobert have been exceptionally favourable, and that the method does not invariably lead to economies. He also alludes to the inconvenience to private consumers of temporary fluctuations in pressure.

An article in *The Progressive Age* describes the GROWTH OF HIGH-PRESSURE GAS LIGHTING IN THE UNITED STATES, and a recent number of *The Journal of Gas Lighting* draws attention to the development of networks spread over an immense area and the transmission of gas to very long distances. For example, the generating station at Lübeck, in Germany, transmits gas under a considerable pressure to Travemünde, 30 miles away, and gas is also supplied from the station in Berlin to suburbs at a similar distance.

A number of other articles in the United States press deal with such subjects as MODERN GAS FIXTURES and MODEL DISPLAYS OF DEMONSTRATION LIGHTING. On the other hand, the *Zeitschrift für Beleuchtungswesen* expresses dissatisfaction at a recent display of this kind in Berlin, and argues that a central organized depôt is needed to deal with the matter on satisfactory lines.

A recently published report of the Lichtmesskommission of the Deutscher Verein von Gas und Wasserfachmännern deals with SAFETY LAMPS. A distinction is drawn between the conditions to be fulfilled in mines and gasworks, and further experiments are suggested to determine more precise safety regulations and values of intensity.

The usual articles dealing with liquid fuels for incandescent burners are continued in the *Zeitschrift für Beleuchtungswesen ;* the summary of patents on inverted burners is now concluded.

Several recent articles draw attention to NEW DEVELOPMENTS IN ACETYLENE LIGHTING. For instance, it is stated that dissolved acetylene is being found very useful for lighting beacons, &c., on the South Pacific coasts, and the Hungarian State Railways are experimenting on a large scale with this method of lighting carriages. In recent numbers of *Acetylene* attention is drawn to the need for THOROUGHLY GOOD PIPING. There is a tendency to save, perhaps, 5 per cent on the installation by using lead and composition pipes. But this is easily damaged and sometimes gnawed by rats, with the result that serious accidents, which might have been entirely prevented by proper workmanship, have occurred.

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CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

The Fire at the Brussels Exhibition.

THE fire which occurred last month at the Brussels Exhibition, and which led to the destruction of so many valuable exhibits, has naturally caused great concern in this country.

We feel bound to take this occasion of expressing our sympathy with the exhibition authorities, and with those who have sustained such heavy losses and disappointment. It may be added, however, that all concerned appear to be showing great energy and courage in reorganizing the portion of the exhibition which has suffered, and we hope that much of the damage may be made good even though serious loss is inevitable.

We notice that, while the exact cause of the fire seems to be uncertain, there is a tendency to ascribe it vaguely to the "fusing of an electric wire." This suggestion is put forward —somewhat unreasonably—in many cases in which the real cause of the outbreak is not known. That defective electric wiring can lead to such dangers is of course thoroughly recognized, but it should also be admitted that this danger can be avoided if only proper material is used, the work is carried out in a satisfactory manner, and the necessary care and expense are not grudged.

It should be remembered, too, that the very ease with which electric lighting can be applied for decorative purposes sometimes leads to its misuse. Electric glow lamps, being completely enclosed, are often utilized in positions in which it would be clearly out of the question to place a gas lamp. On the other hand, a serious leakage of gas, since, unlike electricity it gives rise to a pronounced odour, is likely to be detected at an early stage. It is very essential to ensure that an electrical installation is thoroughly satisfactory at the commencement.

Provided certain reasonable precautions are observed the method readily lends itself to these decorative uses. But occasionally the habitual successful use of electric lamps in this way leads to over-confidence and the border line of reasonable safety is overstepped. As has been repeatedly pointed out in these columns, it is unwise to place even electric glow lamps in immediate proximity to inflammable material. It is the abuse of the light in this way that occasionally leads to disastrous fires and tends to give rise to an impression of insecurity.

In exhibitions, however, the arrangements have sometimes to be carried through under great pressure. Large areas have to be lighted, and the question of cost is a serious one. The risk entailed by imperfect workmanship is accentuated by the temporary nature of many of the buildings, which are often flimsily constructed and liable to catch fire in the event of an electric defect making itself evident.

The only remedy seems to lie in the recognition that a higher standard of care is necessary, and that in framing conditions for the lighting arrangements specially stringent precautions should be observed. In the case of exhibits of special value it would seem desirable to make the buildings housing them as fireproof as possible. In planning the general arrangements of the exhibition, too, it would be preferable for the different sections to be isolated, so that a fire can be more readily localized and dealt with.

In conclusion it may be pointed out that the method of illuminating the exteriors of buildings by indirect methods, instead of outlining them by innumerable glow lamps, seems to offer advantages from the standpoint of safety as well as that of decoration.

A Museum Devoted to Illumination.

We have previously had occasion to draw the attention of our readers to the elaborate Museum at Munich devoted to methods of lighting and illuminating apparatus. During the last visit of the writer to Germany he had an opportunity of inspecting this Museum, and also the other great National Museum in this City, which is also devoted to technical and scientific apparatus. An account of some features of these museums will be found on page 539 in this number.

In matters of illumination there are weighty reasons to advocate the maintenance of a special Museum devoted to collections of lighting apparatus. Here we should be specially anxious to preserve the chain connecting the traditions of the past and the achievements of the present complete, and not to lose sight of the gradual evolution which has led to the methods of illumination to the present day. For the design of illuminants and fixtures is a complex subject. It is not enough to provide light and to distribute it in a scientific manner. There are always present in the mind recollections of the modes of illumination of the past and artistic conceptions which are associated with the traditions of bygone ages, and a properly equipped and organized museum provides a valuable record of all these stages of development through which illuminants have passed. An illuminating engineer who not only seeks to make illumination more scientific, but also recognizes in it a subject for artistic treatment, may derive inspiration by studying ancient forms of lamps and fixtures, and needs to understand more fully how they have developed into our apparatus of the present day. In this connexion we may recall the review of the excellent work by Lieut. von Benesch, which was published in a recent number of this journal (*Illum. Eng.*, Vol. II., Sept., 1909, page 631). By studying such records we realize how men in the past were willing to bestow loving care on the details of artistic designs, even though they dealt with illuminants which, for the purpose of shedding light, may now seem inadequate to a degree.

There is one feature, too, in these Museums in Munich which deserves special commendation. Those responsible for the organization of these institutions are not content to place objects in a glass case and label them with a more or less inadequate printed description. Arrangements are made to enable the visitor to light up any lamp which he would like to see in action. Measuring instruments are provided by which information can be gained as to their efficiency. Gas lamps are shown in working order with meters and pressure-recording instruments in action, and demonstrations of the effect of different types of shades and reflectors are undertaken. There is even a room fitted for the photometrical bench, where a visitor can gain some insight into the process of photometry. It may truly be said that a visitor to a Museum organized on this principle really learns, and does not, as is too often the case, go away with a confused series of mental images which are rapidly obliterated.

One other improvement introduced by the authorities deserves special mention. Trained guides, having an acquaintance with foreign languages and special scientific technical knowledge of the exhibits, are available for visitors from foreign countries. Facilities in this direction are specially welcome, and should go far to make the exhibits interesting and attractive.

The Visit of the German Institution of Gas Engineers.

We refer elsewhere to the approaching visit of the members of the German Institution of Gas Engineers, who are to be the guests of the corresponding institution in this country, and of various British Gas Companies at the beginning of next October. It will be recalled that last year members of the English Institution paid a visit to Berlin and were similarly entertained by their German confrères.

We should like to take this opportunity of voicing the friendly feeling of all those interested in illumination towards our visitors, and we hope their stay will be a thoroughly enjoyable one. Nothing can be more helpful to the spread of knowledge and mutual understanding in connexion with illumination than this interchange of courtesies between engineers and scientific men in different countries. During the last few years we have seen a marked development of the international spirit in scientific circles. Any progress in one country now becomes a matter of interest and discussion in another, much more rapidly than would have been thought possible but a few years ago. It may be recalled that a great deal of the recent progress that has been made in gas-lighting is due to the patient work of German scientists and engineers, and the high-pressure system of Berlin has long been regarded as one of the earliest and best examples of street lighting by gas.

We feel confident that both nations can only profit from such opportunities for the interchange of knowledge, and we hope that the approaching visit of our Continental friends may be followed by many others in the future.

Responsibility in Fixture Design.

An interesting point in connexion with fixture design was raised in a recent number of our contemporary, *The Illuminating Engineer* of New York. From time to time in the past there have arisen men whose artistic perceptions and ability as craftsmen enabled them to achieve special distinction in decorative art. Thus there are names which will always be associated with certain developments in styles of architecture or with certain schools of design in furniture and decoration. The work of these men was so characteristic that even to-day an expert can recognize their handiwork at a glance.

Why should not a similar state of things exist in connexion with the design of lighting fixtures? In the past, no doubt, to some extent it did. The lighting fixtures were then re-

garded as an essential part of the general scheme of decoration, and often received as much care and embellishment as was lavished on the decoration of the interior which they served to illuminate. What is there distinctive about the large class of fixtures which are turned out to-day without any indication as to who was responsible for their design? Nevertheless it is difficult to imagine a line of work in which the capabilities of the designer, in reconciling practical utility and artistic finish, are more nicely blended. There is a great opportunity in this work for men who possess the necessary artistic instinct, the more so because our illuminants of the present day enable us to do much that was almost impossible in the past.

But with our greater facilities in light distribution there have also come new responsibilities. One not infrequently comes across instances in which some old design of fixture has been effectively imitated as regards appearance, but without any consideration for the fact that it is now to be used in connexion with the electric lamp.

Again, there are probably comparatively few examples of fixtures in existence in which the designer has succeeded in giving effect to the claims both of artistic appearance and efficiency as a distributor of light.

It may be added that the above remarks apply equally to many types of shades and reflectors and glassware generally. The importance of good design from the standpoint of light distribution is perhaps even more vital in this case; and here again one would like to see introduced more fully the element of responsibility for certain designs, somewhat in the same way, for example, as the word "Holophane" has come to be associated with glassware scientifically designed for purposes of illumination.

Naturally shades and reflectors, as well as the fixtures utilized for their support, have to comply with both æsthetic and utilitarian principles.

What is needed at the present time is a number of designers sufficiently educated to appreciate the relative importance of all these different factors. Such a knowledge can only be gradually acquired, and there are probably only a few, if any, men at the present time who possess it. We hope in the future that the discussions of the Illuminating Engineering Society, by facilitating the exchange of views of architects, engineers, and fixture designers on such subjects, will help to bring about a better state of things.

The Congres International des Maladies Professionelles.

Readers of this journal will recall that the above important congress is to take place in Brussels during the month of September. The Illuminating Engineering Society is to be represented by several delegates on this occasion, and a paper is to be presented by the Hon. Secretary of the Society on 'The Hygienic Aspects of Illumination.'

The work of the congress, dealing as it does with important questions of industrial hygiene, is naturally of considerable interest to our society, and it is satisfactory to note that the subject of illumination will be prominently brought forward. A very considerable proportion of the large number of papers to be submitted by representatives of the medical profession of different nations at this congress, copies of which we have now before us, deal with the prevention of industrial diseases and the Workmens' Compensation Act. Other contributions deal directly with the effect of illumination on vision, the hygiene of the eye, the causes and nature of cataract, &c.

We mean to comment more fully on the work of the congress in another issue. Meanwhile we take the opportunity of drawing our readers' attention to its important and extensive programme, which, we hope, will bear good fruit. LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 535) concludes the section of his article dealing with the illumination of various streets in London, theatre lighting, &c. He then proceeds to the discussion of Errors in Photometry, which he divides into various classes, *e.g.*, those due to mistakes on the part of the operator, those due to inaccuracy in the apparatus, &c. He also gives an account of the theory of the calculation of the mean error in a single observation. In the next instalment of the article some sources of personal error will be considered.

Following this (p. 539) will be found an account of the section of the Museum at Munich devoted to Illumination. The method of displaying exhibits is unique in several respects, and a very complete collection of lamps of different periods exists. For example, a section of the Museum is devoted to tracing the development of street lighting. Some illustrations of this portion of the buildings are given, and the value of such collections of ancient fixtures to the designer of the present day is pointed out.

Dr. F. K. Richtmyer (p. 543) resumes his article on Instruction in Illuminating Engineering. In the previous instalment stress was laid on the need for practical measurements of illumination in interiors in addition to purely photometric experiments. In the present section the author describes how the students at the Cornell University studied the experimental illumination in a room specially used for the purpose, utilising the Weber Illumination Photometer in doing so. He illustrates his remarks by reproductions of the actual results obtained by the students.

A paper by **Dr. E. B. Rosa** and **Dr. G. W. Middlekauff** (p. 547) deals with Incandescent Lamp Standards. The authors lay stress on the value of a series of such standards as a means of preserving the unit of light, and describe some experiments showing that excellent results can be secured by testing the lamps at constant power consumption.

It is interesting to notice that it can often be ascertained whether a lamp has been imperfectly aged or no by observing the small change in current during ten minutes' burning, without measuring the light from the lamp at all.

Mr. L. Wild (p. 549) describes some experiments on the Box Integrating Photometer. It will be recalled that Dr. W. E. Sumpner suggested that a square box might be simpler to use in practice and quite as exact as a globe photometer. Mr. Wild now describes some tests of such a box. It was found that the position of the lamp in the box could be altered considerably, and it could be placed with its filament either vertically or horizontally without any very serious error being found to exist. His experiments therefore tend to confirm the suggestion that fair commercial accuracy can be expected from a box of this description.

A paper by **Mr. S. E. Doane** (p. 552) deals with the Metallic Filament Lamp Situation. He suggests that the right method of examining the effect of the introduction of metallic filament lamps on central station revenue is to analyse and subdivide very carefully the cost per unit. He presents tables showing the effect of the more or less complete adoption of metallic filament lamps, and arrives at the conclusion that supply companies may hope ultimately to benefit considerably by their general introduction.

On page 557 will be found an account of a lecture recently delivered by **Dr. N.**

Bishop Harman on SCHOOL LIGHTING. He points out by the aid of diagrams several commonly occurring faults in the artificial lighting of schools such as, for example, crowding the lights together centrally. A minimum intensity of 1 foot-candle is essential, and it is also very desirable that the light should come from the right direction. In any case there are many classes of work which, he considers, should not be attempted in the case of small children except by daylight. As a rough means of testing whether the illumination is sufficient, he suggests an acuteness of vision chart. He also explains a method of testing the degree on eye-fatigue by observing the inclination of the persons studying to adopt binocular vision.

Following this will be found (p. 559) a note on the SENSITIVENESS OF DIFFERENT EYES TO ULTRA-VIOLET LIGHT. Some work is described which suggests that ultra-violet rays are absorbed to a considerable extent by the lens of the eye. This is partly the explanation why such light does not appear visible to the average person. According to some observers the gradual absorption of ultra-violet rays tends to produce cataract.

Dr. W. W. Coblentz (p. 561) again discusses the nature of RADIATION FROM VARIOUS METALS such as platinum, tantalum, tungsten, and molybdenum. He presents curves showing the reflectivity and emissivity for light of different wave-length, and suggests that the comparatively high luminous efficiency of filaments of these materials may be ascribed to low emissivity in the infra-red. In conclusion he points out that it is desirable that the incandescent solid illuminant of the future should emit as little infra-red radiation as possible and withstand a high temperature. Even the best metal at present used complies imperfectly with these conditions and has other defects, such as being inconveniently fragile.

Following this will be found an article from an Engineering Correspondent dealing with the STANDARDIZATION OF GAS SUPPLY. He traces the gradual evolution of legislation affecting the testing of gas, and shows how many of these methods have been condemned as not affording a picture of the capacities of the gas for practical services. Finally, he comments upon the legislation recently requested in order to bring the various methods of testing to a common basis. At the conclusion of this article will be found some notes on some of the EARLY GAS COMPANIES formed at the beginning of the last century. It is interesting to observe that the consumers at that time were at liberty either to have their gas supplied through, and measured by a meter in the usual way, or to use specified burners for certain periods. This note is followed by a reproduction of the exact conditions of supply issued by the Independent Gas Light & Coke Company in 1825.

An article by an Engineering Correspondent (p. 570) deals with the ILLUMINATION OF FLOWERS, &c., where the correct revelation of colour is exceedingly important. In flower shows, for example, choice varieties can only be judged by daylight conditions. There are, however, cases in which the flowers are intended to be shown by artificial light, and if purchased during the daytime for use on the dinner table may not give rise to the correct impression.

On p. 573 will be found a series of SHORT NOTES dealing generally with VARIOUS ASPECTS OF ILLUMINATING ENGINEERING.

Other short articles in this number deal with such questions as the Effect on the Vision of Engine Drivers of LOCOMOTIVE HEADLIGHTS, the Importance of Public Lighting from the Standpoint of Security against Crime, the Illumination of Skating Rinks, &c.

At the end of this number will be found the usual REVIEW OF THE TECHNICAL PRESS (p. 582).

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Illumination, its Distribution and Measurement.

By A. P. Trotter.

Electrical Adviser to the Board of Trade.

(*Continued from p. 483, Vol. III.*)

Ordinary Streets, Theatre-Lighting, &c.—Measurements of the illumination in streets lighted by the ordinary "flat flame" gas lamp were made on several occasions. The illumination was so very feeble that exact measurement was very difficult. The maximum rarely exceeded 0·9 foot-candle. The illumination near the foot of an ordinary gas lamp is very irregular, and is much cut up by shadows of the lantern frame. Fig. 138 is the illumination curve along the curb of the foot pavement of Great George Street, Westminster. A slight increase midway between the lamps is due to a lamp on the opposite side of the street. The minima were about 0·005 foot-candle, an illumination a little greater than the value calculated by the cosine-cubed law. This was probably due to the reflection from surrounding buildings, or to general diffused light.

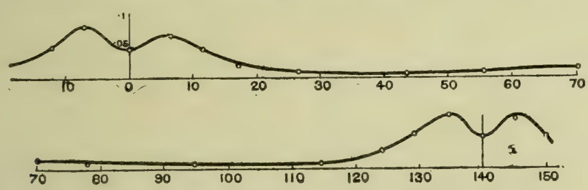


Fig. 138.

The illumination on the stage of the Lyric Theatre during the performance of 'La Cigale' was 3·8 foot-candles without the arc or lime lights. On the stage of the Prince of Wales Theatre during the performance of 'Maid Marian' the illumination was 2·9 foot-candles. The illumination in the trains of the Metropolitan and District Railways was measured on many occasions, and varied from 0·3 to 0·9 foot-candle, the photometer being held breast-high.

Characteristic Curves.—The results of the above-described measurements are summed up in Fig. 139 as characteristic curves.* The ordinates are foot-candles, and the horizontal scale is a percentage scale of areas. The maximum is 100. No. 1 is the characteristic of Queen Victoria Street, on the assumption that the lights are all burning at their best, as in curve C, Fig. 125. No. 2 is the characteristic of the same street, on the assumption that the lamps are at their worst, having just fed. No. 3 is the characteristic of Whitehall, the moonlight having been deducted. It appears that about one-half the area was better lighted than Queen Victoria Street. No. 4 is the characteristic of an ordinary gas-lit street. No. 5 is the characteristic, estimated approximately only, of the Architecture Court of the South Kensington Museum.

* See Vol. II., p. 535.

ERRORS.

The science of photometry consists in intelligent apprehension of the principles of the subject, the art of photometry lies in skilful avoidance of errors. One man may have a thorough knowledge of the theory, may be able to treat it mathematically, may be familiar with apparatus ancient and modern, and yet may be unable to measure the candle-power of a lamp without making errors or mistakes amounting to 8 or 10 per cent. Another, practising photometry as a trade, totally ignorant of the law of inverse squares, or any other theory, may be able to make his own sensitive Bunsen screens and test several thousand lamps a day without exceeding the limit of error, say 2½ per cent.

By a peculiar ambiguity in our language an "accuracy of 1 per cent" is often used to express the degree of correctness of a measurement, when an error of 1 per cent is implied. The word "precision" is perhaps better than "accuracy," because it allows of degrees of comparison. An expression is either accurate or inaccurate: it cannot be said to be rather accurate; it may be said to be almost accurate.* But common usage sanctions "highly accurate" and various degrees of truth and honesty. Errors with which we are here concerned are the results of attempts to make a measurement under difficult circumstances. It is possible, but very improbable, that the true value may be obtained by any one measurement. There are several different kinds of errors: they may be divided into two classes, variable and constant. Variable or personal errors depend on the individual. Constant errors relate chiefly to the instrument or mode of measurement.

Some writers speak of known and unknown errors. If an error is known, it can be allowed for, and should be called a correction, not an error. It is not easy to make a clear distinction between errors and mistakes. Errors are inversely proportional to skill; mistakes, to carefulness. If the scale is read through an opening in the moveable carriage of a bar photometer, the opening should be wide enough, or the numbering of the scale should be full enough, to allow at least two fully numbered divisions to appear in an opening. In Fig. 140 it is easy to make the mistake of reading the indication as 921 instead of 879. That would be a sheer mistake or blunder.

In using a Hefner or Harcourt lamp

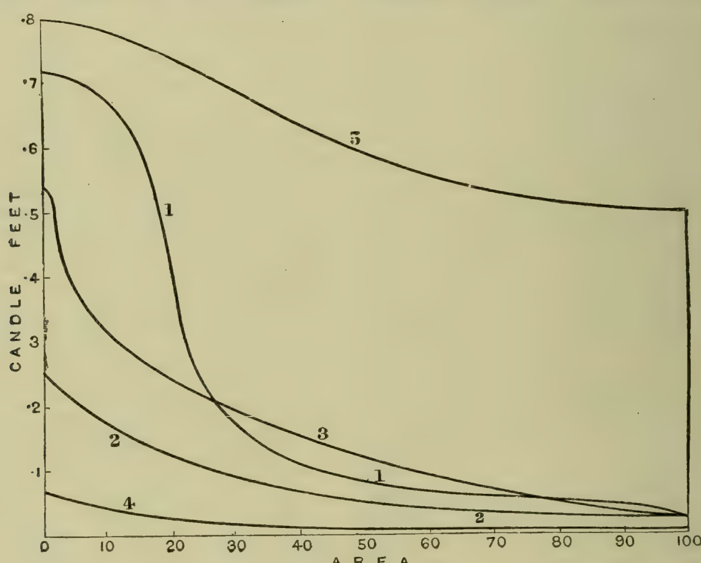


FIG. 139.

* For a general discussion of accuracies and errors see an article by the author, *Electrical Engineering*, vol. i., No. 1, p. 21, from which parts of this section are extracted.

as a standard of light, inaccuracies will be introduced if correctness for atmospheric pressure, moisture, and CO_2 are neglected. It may be said that to neglect such corrections is a mistake, but their importance depends entirely on the precision aimed at, and if it is decided to neglect them, the inaccuracies become errors of the mode of measurement chosen. In investigating the ageing of an electric glow-lamp or of an incandescent gas mantle, by taking measurements from time to time against a flame standard, the corrections should be made, but it would be better to avoid them by using a sub-standard electric lamp which is used only when measurements are in progress. For checking a portable photometer before starting for an evening's work out of doors in measuring candle-power, a single test against an uncorrected flame standard is sufficient, for uncontrollable errors due to light reflected from buildings, and to uneven glass of globes or lanterns will mask the small errors due to neglect of the corrections.

Personal errors differ very considerably from instrumental. Personal errors in photometry depend upon such matters as the following:—1. Familiarity of the worker with the particular form of photometer used. 2. General experience with photometric work. 3. Physical condition of the worker. 4. The speed of working, or in other words, the time allowed for each measurement. 5. The colour difference. 6. The steadiness of the light. 7. The illumination on the photometer.

The quantity which measures the degree of precision or accuracy is the error. The application of the artificial mathematical theory of errors is of little use in ordinary scientific work, and is futile in industrial measurements where the object is to obtain a numerical result and an idea of its accuracy or trustworthiness.

If, on the one hand, the object is to compare the combined accuracy of an instrument, of a method, and of an observer, with some other such combination, the "mean error of a single observation" may be calculated. If, on the other hand, it is desired to know the accuracy of the mean of a number of observations made under the same conditions, the "mean error of the result" should be found. The errors of the observations are found by comparing the differences between each of a number of observations and the mean of those observations. The differences are then the object of the investigation, and the mean is the standard to which they are referred. In calculating the mean error of the result, the result is the object of the investigation.

For the former of these two objects, namely, to ascertain the accuracy of a method, the tedious rules for finding the so-called probable error must be employed. The investigation of Kennelly and Whiting, to be referred to later, was of this kind. Twenty-five repeated observations of the same quantity is about the smallest number from which a probable error can be reasonably computed.

For all ordinary purposes the mean difference from the mean of a set of observations suffices to measure the precision. To find this, take a number of successive measurements made under precisely similar conditions, and take the mean. This gives the most probable result.* No amount of mathematical theory of errors can produce a more plausible result from this material. The only way to improve it is to take more measurements.

The first column of the following tables gives a set of ten observations which I made with a perforated screen photometer. I consider them good, but I have made better.

	d	d^2
1·089	—·0004	·00000016
1·086	—·0034	1156
1·087	—·0024	0576
1·095	+·0056	3136
1·090	+·0006	0036
1·093	+·0036	1296
1·095	+·0056	3136
1·082	—·0074	5476
1·089	—·0004	0016
1·088	—·0014	0196
1·0894	·00308	·00001504

* If all the results are ranged in order of magnitude, the middle one has some claim to be the best, but the selection and re-writing takes more time than adding and dividing by the number of results.

The mean is 1·0894. The last figure, 4, is beyond the possible range of observation, and should not be recorded as a significant figure. The second column gives the difference between each observation and the mean. The eighth difference is large, but not large enough to warrant discarding the observation as a mistake. The mean of these differences, or residuals as they are sometimes called, is 0·00308. The mean difference from the mean is therefore about 0·3 of one per cent. That is sufficient for all ordinary purposes as a measure of the accuracy of the observations.

The calculation of the mean error of a single observation, of the mean error of the result, and of the so-called probable values of these quantities is rarely worth the trouble, for two reasons at least. In the first place such values deduced from so few observations as 10 are only approximations, and in the second place, few people can spare time to make more than 10 observations of a single quantity, unless

FIG 140.

for very special purposes. The "probable error of a single observation" is smaller than the simple mean difference from the mean, and may be used for purposes of argument to show that your work is better than somebody else's.

The following working out of these values is intended rather to show that little if anything is to be gained by the trouble for ordinary industrial work. There are two recognized rules for the computation.*

According to the well known and more rigorous rule,

$$e=\sqrt{\frac{\Sigma d^2}{n-1}} \qquad E=\sqrt{\frac{\Sigma d^2}{n\,(n-1)}} \qquad (1)$$

where e is the mean error of a single observation, E the mean error of the result. Σd^2 the sum of the squares of the differences paying no regard to sign, and n is the number of observations. The probable errors are two-thirds of these. A probable error does not mean one that is probable. It is an unfortunate expression. It means that the chances are even for and against any given error being greater or less than the corresponding probable error.

The other rule* is an approximation, and dispenses with the squaring of the differences.

$$p.e.=0{\cdot}8453\,\frac{\Sigma d}{\sqrt{n\,(n-1)}} \qquad p.E.=\frac{p.e.}{\sqrt{n}} \qquad (2)$$

where $p.e.$ is the probable error of a single observation. Σd is the sum of the differences, and $p.E.$ is the probable error of the result.

A third, and an extremely simple rule may be derived from this when $n=10$.

$p.e.=\Sigma d\times 0{\cdot}089 \qquad$ p.E.$=\Sigma d\times 0{\cdot}028$

The errors of the set of ten measurements already given work out as follows :—

(1) The mean difference from the mean .. 0·00308
Mean error of a single observation
$=\sqrt{\frac{0{\cdot}00015}{9}}=$ .. .. 0·0041
Mean error of the result$=\sqrt{\frac{0{\cdot}00015}{90}}=$ .. 0·0013
Probable error of a single observation= 2/3 of 0·0041= .. .. 0·00272
Probable error of the result=2/3 of 0·0013= 0·00086

(2) Probable error of a single observation=
$0{\cdot}8453\,\frac{0{\cdot}00308}{\sqrt{90}}=$ .. .. 0·00274
Probable error of the result$=\frac{0{\cdot}000274}{\sqrt{10}}=$ .. 0 000866

(3) Probable error of a single observation=
0·0308 × 0·89= .. .. 0·00274
Probable error of the result=0 0308 × 0 28= 0·00086

In the ordinary work of testing lamps in a factory, measurements are not repeated unless it is suspected that a mistake has been made. In some work such as the plotting of a rather irregular polar curve of candle-power in different directions, it may be better to make a single measurement at each of a large number of angles, than to repeat observations at the same angle for the purpose of taking the mean, and securing greater accuracy.

The foregoing numerical expression of errors is tedious, and not very informative. The precision of a set

* *The Principles of Science*, Jevons, vol. i., p. 452. *Adjustment of Observations*, Wright and Hayford. *The Theory of Least Squares*, Mansfield Merriman. *Physical Measurements*, Kohlrausch, Third English Edition, p. 2. *Notes on Observations*, S. Lupton.

* Peters' formula. *Astronomische Nachrichten*, vol. xliv., p. 32 (used by Kennelly and Whiting).

of observations may be clearly indicated when the result is plotted as a curve by recording each observation, good or bad, as a dot or a little circle, and drawing a curve evenly among them. When a curve is drawn from calculation it is not necessary to record the calculated points. The reader must assume that the author has calculated a sufficient number of points to warrant the drawing of the curve. But when a curve is drawn from experiment it is the duty of the author to place the observations before the reader. The author draws the curve which appears to him to show the result, but the reader should have an opportunity of satisfying himself that the curve is a good fit for the observations, and he is enabled to judge of the precision of the work by the distribution of the observed points. Where several observations are made under the same conditions, the mean of these may be taken and indicated by a single point, for in general they lie so close together that they could not easily be distinguished. Fig. 78 is drawn in this way; each point represents the mean of ten observations. Fig. 85 shows the separate observations of one of these sets. Fig. 103 shows a curve drawn through 31 single unrepeated observations.

For ordinary scientific work, not less than three observations should be made for any given condition. Theory shows that the accuracy increases only as the square root of the number of observations; it is therefore not worth while to make more than 10, the number most convenient for averaging.

Having discussed what is meant by error, we shall proceed in the next article to consider some of the sources of personal error.

(*To be continued.*)

A Museum Devoted to Illumination.

In this journal reference has frequently been made to the importance of a knowledge of the historical side of the development of illuminants and systems of lighting. In dealing with the illumination of interiors having any æsthetic and architectural pretensions an expert is needed, possessing a thorough knowledge of the development of the subject of illumination in the past, and designers of to-day could often learn much by the study of the old decorative fixtures of the Middle Ages.

A museum in which these various stages of development can be traced, and examples of all the ancient types of lamps and fixtures preserved, would therefore be of considerable value, and it occurred to the writer that some account of the great museums in Munich, based on a recent visit and on information kindly supplied by the authorities, might be of interest.

There are several features in the famous museums of Munich which deserve special mention. Not only are the exhibits in themselves exceptionally complete, but the method of exhibiting them to the public is also in many respects unique. For example, the information attached to each item is exceptionally complete. But, more than this, the sections devoted to scientific apparatus have been very carefully thought out with a view of showing the apparatus in actual operation. The Röntgen ray apparatus, for example, can be put in actual operation and its effects observed by any visitor by merely pressing a button. In the same way the visitor can observe for himself through a spectroscope the spectra of the various metals and gases, even such comparative novelties as helium, argon, neon, &c., being available. The advantage to the scientific student of having such a series of actual spectra at his disposal is obvious. It need not be said that considerable ingenuity must have been exercised to render these scientific experiments, many of which present considerable difficulty to the student in the laboratory, so

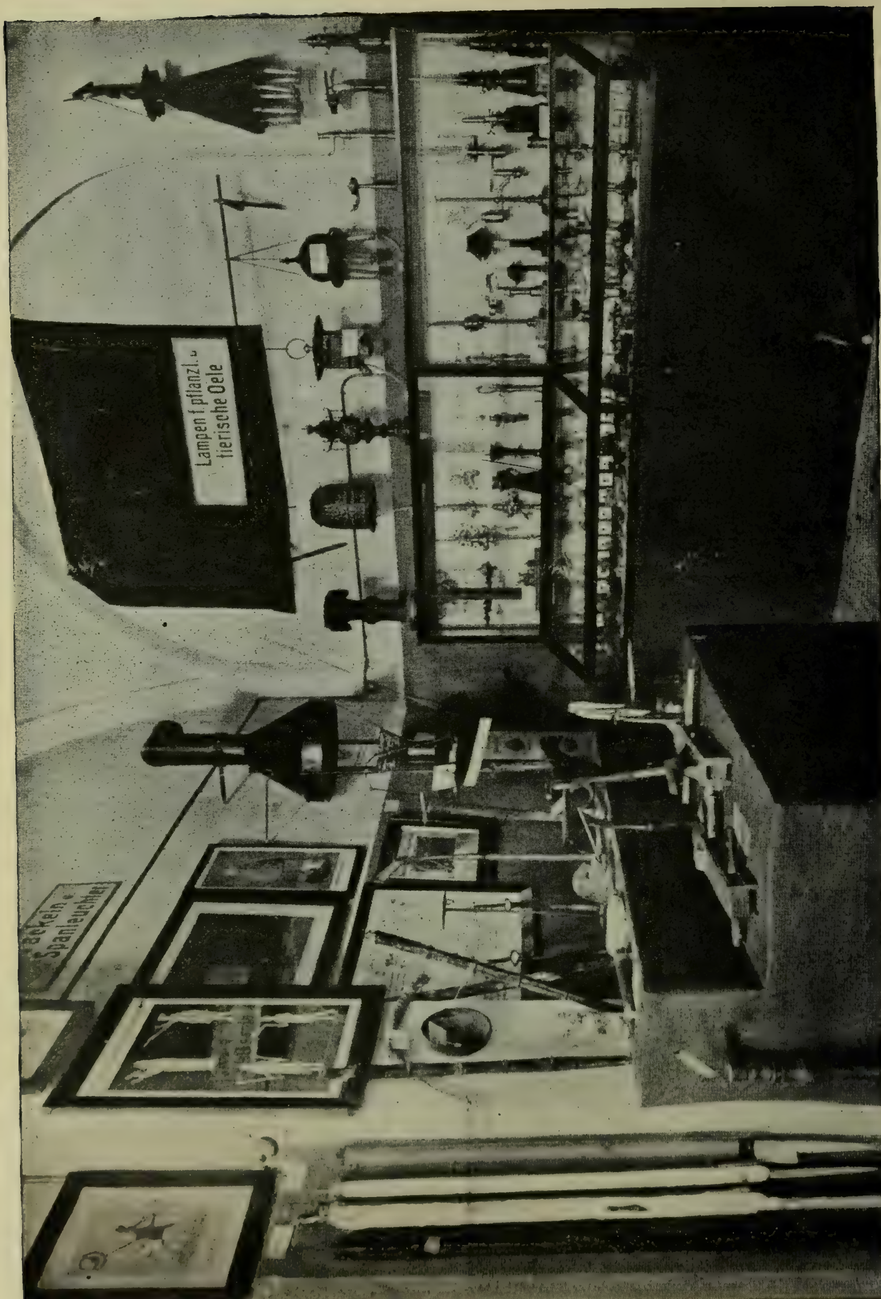


Fig. 1.

Section of the Munich Museum devoted to Illumination. A collection of old fixtures using inflammable wood splinters, and old oil lamps is shown.

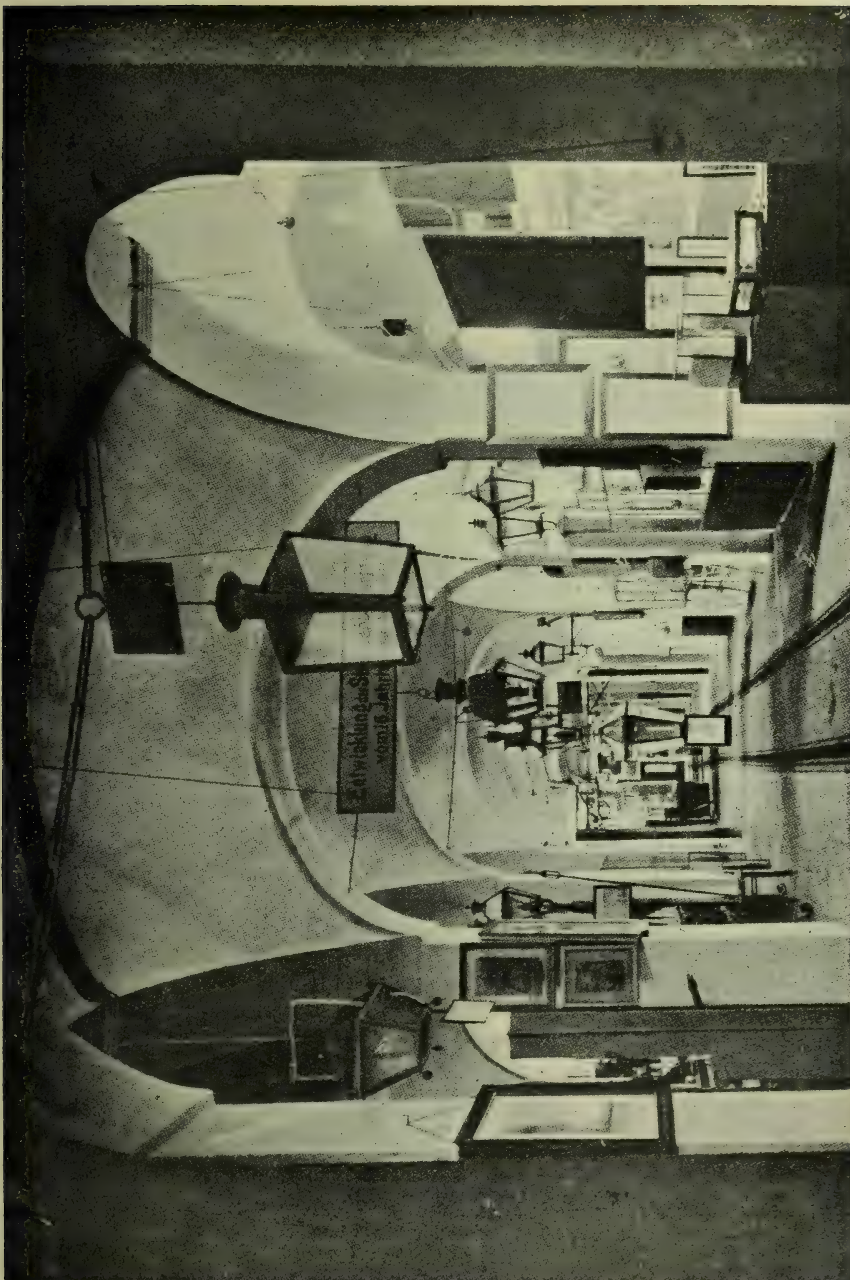


FIG. 2.

Section of the Munich Museum devoted to Illumination. The illustration shows a collection of lamps intended to exhibit the development of street lighting.

certain in action as to be exhibited to the general public in this simple way. Another special feature is the provision of complete working models of coal mines and various industrial operations, in which the actual processes are carried out mechanically.

Of the greatest interest, however, is the section of the museum devoted to illumination. This is organized on a thoroughly historical system. A general view of this portion of the Museum is shown in the accompanying illustrations. Passing down this room the visitor can trace the gradual development of the lighting from the use of the old pine splinters of a century ago down to the newest lamps of the present day. In Fig. 2, for example, the readers can note the antique iron lamps, in the foreground, and, but a short distance away, a series of inverted arc lamps. Passing through this portion of the Museum the visitor traces the development of the candle, oil lamps, and gas lamps up to the most recent inverted incandescent burners, and can also follow the corresponding simultaneous developments in electric lamps. Recourse is also had to old prints showing the application of these lamps in times gone by. For example, one illustration shows the lighting of an art school in Berlin 200 years ago by means of an iron basket containing pine splinters. One may imagine that the flickering shadows of this system of lighting would have been found very inconvenient by the students of to-day. A special section of the Museum is also devoted to the development of street lighting, the gradual transition from the early oil lamps and beacons to high-pressure gas lamps and flame arcs of to-day being shown.

It may be added that all these lamps are not locked away in inaccessible glass cases; most of them can be actually lighted up, and the observer can readily gain an impression as to the illuminating power of many of these old sources. Apparatus is also provided to enable him to ascertain the consumption of gas or electricity. By pressing a button a lamp can be lighted up with the various instruments attached thereto, showing the pressure, gas consumed, &c. For example, a series of the latest incandescent glow-lamps are mounted side by side. They can be lighted up in succession by the visitor, who can observe the electrical pressure, power consumed, and current in each case. A photometrical room is even provided where measurements of candle-power can be made. The contents of this museum are kept thoroughly up to date, new lamps of all descriptions, gas, oil, acetylene, electric, &c., being continually presented as they are put on the market.

It need hardly be said that such a museum requires considerable supervision. A special feature has recently been introduced for the benefit of visitors, namely, special trained guides who speak several languages and have a scientific and technical knowledge of the exhibits, and whose services can be secured at a nominal fee.

The Electrical Standardizing, Testing, and Training Institution, Southampton Row, London, W.C.

Appointment of Secretary and Business Manager.

Mr. Howard Foulds, who for sixteen years has occupied the position of Secretary and Business Manager of the Electrical Standardizing, Testing, and Training Institution, Faraday House, having been appointed to the new post of Secretary to the Electricity Department of the City of Birmingham, the Governors have filled the vacancy by the appointment of Mr. Ernest A. Nash. Mr. Nash, who was one of the earliest supporters of the Illuminating Engineering Society in this country, has been with the St. James's and Pall Mall Electric Light Co., Ltd., for many years, and his experience of modern installations, together with his wide connexion amongst architects and large electric light and power users, should be of considerable value to the Consulting Engineering side of the Standardizing Department of Faraday House.

Instruction in Illuminating Engineering.

By Dr. F. K. Richtmyer.

(Concluded from p. 487.)

In order to bring out in a more concrete manner the relative importance of illumination measurements as compared with the measurement of candle-power, the last experiment in the course—the study of the illumination of a lighted room—is given special emphasis. Not only is this experiment much longer than the others, but the student is made to feel (inductively, of course) that the preceding experiments, involving the study of several photometers, measurements of mean horizontal and of mean spherical candle-power, effect of reflectors, lamp characteristics, &c., are more or less preliminary to this final study of illumination.

The "illumination room" is a small room, approximately 30×19×11 ft., painted *white* and fitted with the following four systems of lighting :—

1. *Distributed direct.* — 12 16-c.-p. lamps suspended with or without reflectors about 9 ft. above floor.
2. *Concentrated direct.*—A single high candle-power source in the centre.

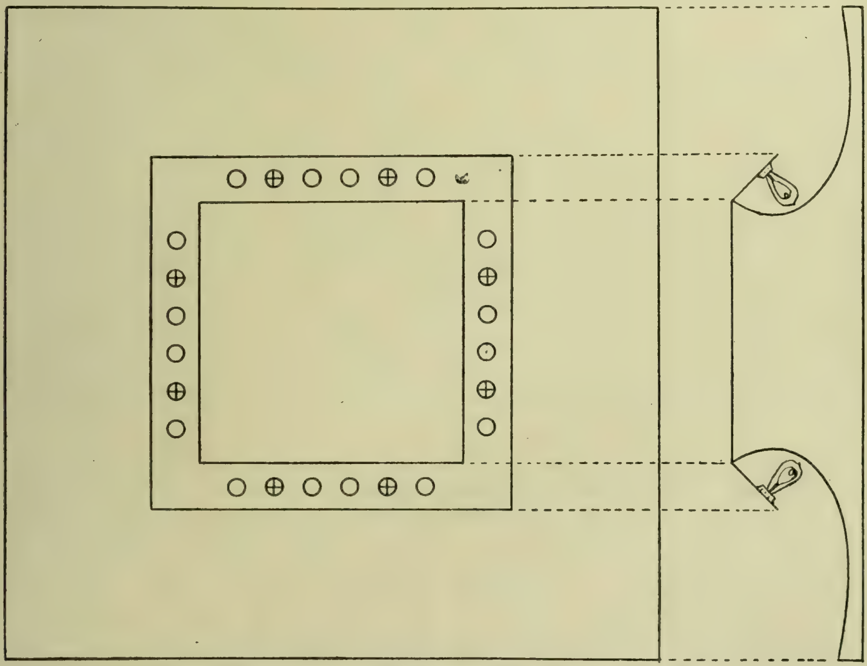


Fig. 2.—Showing specially fixture giving indirect lighting.

3. *Distributed diffuse.*—14 16-c.-p. lamps equally spaced in "coves" at the ends of the ceiling.
4. *Concentrated diffuse.* — A single fixture, of original design, fixed approximately in the centre of the ceiling. This fixture (see Fig. 2) the reflecting surfaces of which are painted a dull white, contains 24 lamps, arranged

in two sets of 2 lamps on a side (those with crosses) and 4 lamps on a side (those without crosses) respectively, so that three diffuse illuminations in the ratio of 1, 2, and 3 can be obtained by using either set or both together.

To illustrate the nature of the work done in this room, a brief description will be given of the test made when the room is lighted by the diffusing fixture just described.*

Following the usual method of making such a test, the floor of the room is laid out in 2-foot squares, the rows of which are lettered north and south, and numbered east and west. See Fig. 4. By means of a previously calibrated Weber photometer adapted for illumination measurements, the was 3·8 ; at F–10 3·8 ; and at H–10 2·4. And the line marked "10" in Fig. 3 thus shows the change of illumination along the east-west row of stations numbered 10. A similar series of curves—not shown—would be plotted for the north-south, *i.e.*, numbered rows of stations.

Now to "run" the equilucial line of say 3 candle-feet, referring again to Fig. 3, line 10, we see that there is an illumination of 3 candle-feet at a point (marked by the arrow), which is about ·6 of the way from B toward C on row 10. The point thus determined is now located on the lay-out of the room. (See point marked by the arrow, Fig. 4.) In a similar way all other points having an intensity of illumination of 3 candle-

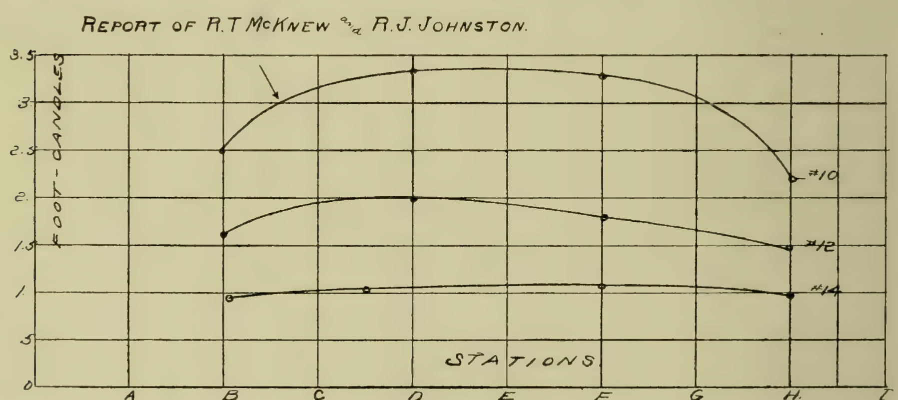


FIG. 3.—Showing distribution of illumination in room lighted by fixture referred to in Fig. 2.

horizontal illumination is measured at the centre of each of these squares, and the average taken as the mean illumination over the entire room.

To represent graphically the distribution of illumination an "equilucial chart" is then prepared as follows: A series of auxiliary curves, three of which are shown in Fig. 3, is plotted with the *lettered* rows of stations as abscissae and the intensity of illumination at each of these stations as ordinates. For example, referring to Fig. 3, at station B–10 the intensity of illumination was found by measurement to be 2·5 candle-feet ; at D–10 it

* All data and curves herein described are taken from the reports of Mr. R. T. McKnew and Mr. R. J. Johnston, to both of whom grateful acknowledgment is made.

feet are located, and these joined by a smooth curve. The complete chart of the room is thus prepared as shown in Fig. 4. The student is asked to note and explain any irregularities : *e.g.*, why, in this case is the intensity of illumination so much higher on the south end of the room than on the north end, although the fixture is practically at the centre of the ceiling, and to suggest means of improving the distribution. In certain cases it is found desirable to carry out these suggestions, and to note whether the effect is as predicted.

In addition to preparing the chart, the following will illustrate some of the computations made. (Taken from the same report.)

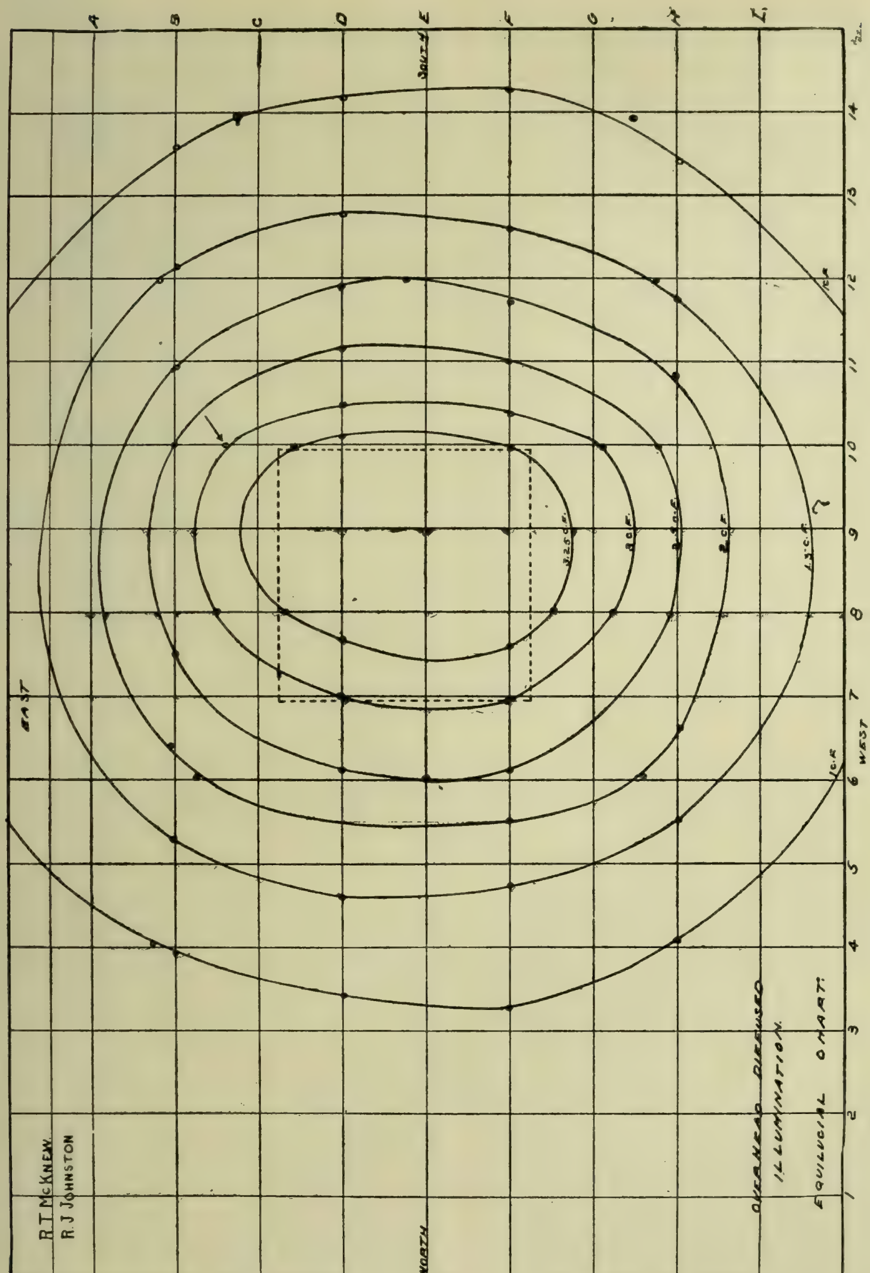


FIG. 4.—Equilucial chart of illumination.

TEST ON CONCENTRATED DIFFUSING FIXTURE:

Average intensity of illumination	1·74 cf.
Area of room	568 sq. ft.
Flux of light through horizontal plane (=1·74 × 568)	990 lumens.
Mean spherical candle-power of lamps	11·8.
Number of lamps	16.
Total flux of light produced (=4π16 × 11·8)	2375 lumens.

Efficiency of installation

$$=\frac{\text{horizontal flux}}{\text{total flux}}= \quad 41{\cdot}7\%$$

Following such a test as this, a test may be made of one of the other systems of lighting in the illumination room, or as is more frequently the case,

a test of one of the other rooms in the building not specially designed for the purpose.

It has been found advisable to leave many phases of the subject entirely unmentioned and to concentrate on a few points, the reason being that if a student has thoroughly solved several problems connected with illumination work he is in a much better position to attack new problems than if his work has touched lightly all branches of the subject.

In conclusion the writer would like to join with the editor of this journal in a plea for more interest and greater unity of action regarding this general subject of education in illuminating engineering. In all science, and in engineering in general, is there not proportionally too much emphasis laid upon the promotion and advancement of the *science* itself, by means of the various societies, journals, clubs, &c., and too little upon the best manner of presenting the fundamentals to the students in our schools? Any one who becomes at all acquainted with the inside workings of any technical school cannot fail to perceive that its educational methods are by no means settled, as the frequent changes in the curriculum abundantly testify. And yet, of all the scientific and engineering organizations, few are devoted even in part to the consideration of pedagogical problems. Truly, the *science* of *engineering education* needs organized investigation and discussion quite as much as engineering science. And cannot illuminating engineering, one of the youngest of engineering sciences, devote some of its energy, and a small part of the space in its journals regularly, to the betterment of its educational methods, and to securing greater co-operation between its teachers and its practising engineers?

The Public Lighting of Paris and its Influence on Safety.

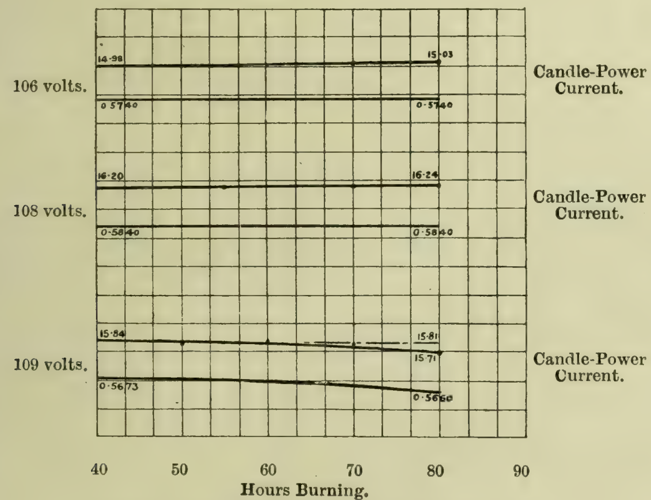
A DISCUSSION on the above subject, which was referred to in a recent number of the *Revue des Éclairages*, shows once again how many-sided are the services which illumination has to render. The main point at issue was the question whether in the interests of public safety a large number of street-lamps at present extinguished at midnight should not remain lighted throughout the night. Discussions on the subject have taken place at the Paris Municipal Council intermittently for the last year or two. As far back as December 31, 1907, M. Lepine is reported to have declared, in answer to a suggestion that certain of the street lamps should be extinguished at midnight, "Darkness is the friend of robbers; the more gas-lamps you illuminate the more successfully you will restrain them from their misdeeds."

Following this several petitions were sent up to the Council (one of them bearing over 20,000 signatures) in favour of abolishing the system of turning out lamps at midnight and making the whole service permanent. Of course, the question of cost could not be lightly dismissed, and it was estimated that the additional cost of maintaining the 14,800 lamps which are now burning on the short time basis, throughout the entire night, would be at least 15,000*l.* per year. However, there seems to be such a strong feeling that the safety of the streets at night would be materially improved by this step that the change will probably be made in the near future. Certainly, hearing, as one does, so much of the apparent growth of crimes in certain parts of Paris, and of the difficulty of suppressing the bands of "Apaches" and their like, one would imagine that the police would be grateful for the assistance rendered by abundant illumination.

Carbon Filament Lamps as Photometric Standards.

In a recent paper presented at the Annual Convention of the American Institute of Electrical Engineers, E. B. Rosa and G. W. Middlekauff described some work on incandescent lamp standards carried out at the Bureau of Standards in Washington. It was hoped, as a result of a very careful study of the seasoning process, and the performances during the subsequent burning of carbon filament lamps, to prepare more constant standards than had hitherto been secured.

Carbon filament lamps have recently and voltage supplied to the lamps were measured very accurately by means of a double potentiometer. The authors point out that the maintenance both of a constant current and a constant voltage, when measured, as in this case, to the fifth decimal place, provides a very sensitive indication that the resistance of the filament is satisfactorily constant. In this way the electrical conditions of the lamp are kept as constant as possible, and the variation in candle-power rendered correspondingly minute. In fact, it



Life Curves of Carbon Filament Standard Lamps.

proved to be very convenient working standards. The authors point out that the light from even the best of flame standards depends not only on the construction of the lamp (which can be reproduced), but on the quality of the fuel used and the state of the atmosphere ; these two elements are constantly changing, and thus a degree of uncertainty is introduced from which the electric incandescent lamp is free.

In making the photometric tests described in this paper, both the current can be ascertained whether a lamp has been properly seasoned or no merely by tracing the alteration in resistance during ten minutes or less, without measuring the light.

It is interesting to note that the authors used a method of automatically recording and taking the mean of the settings of the photometer by means of dots made on a record sheet by depressing a key. This resembles a device recently described in this journal by Mr. A. P. Trotter,* and it is stated that

* *Illum. Eng.*, vol. ii., p. 512.

the method not only eliminates several possible sources of error, but also saves much time and labour—an important point when a large number of photometric observations have to be taken.

Some interesting tests were carried out with the object of determining whether it is preferable to operate lamps during their useful life as standards, at constant voltage (as is usual), or at constant current, or whether still better results could not be obtained by operating at constant watts.

The results of a large number of experiments seem to show that the most perfect conditions are secured when working at constant watts. The life curves reproduced in the accompanying illustration show how important it is in precision photometric work to keep a careful record of the current, and to change the voltage, if the resistance of the filament changes, so as to keep the watts constant. In the first two curves the filaments were unchanged after forty hours of burning, and the light was practically constant.

Naturally a group of lamps can be relied upon, as a means of preserving a unit of light, with much greater certainty than could any single lamp. Rosa and Middlekauff claim that the mean error of the determination of candle-power on any one lamp is only 0·2 per cent. But, as the average of simultaneous measurements of a group of six lamps, an error of only 0·1 per cent is obtained.

The authors conclude that carbon filament lamps, when properly made and carefully seasoned, are remarkably reliable and permanent, and that, with the precision of measurement and the conditions of working of standards such as are described in their paper, the unit of light might be maintained constant for a century by the aid of a single group of lamps.

Locomotive Headlight Tests.

Colour-blindness on the part of railway employees, who have constantly to recognize and distinguish between signals, has long been recognized as a source of danger, to avoid which special tests have been prescribed. In our last number we referred to some suggestions of Dr. Edridge Green on this point.* There is, however, another possible source of personal error which has not received much attention, viz., the effect of very powerful headlights in preventing the engine-driver from clearly distinguishing signals.

A paper on this subject, giving the results of a large number of tests, was recently presented to the American Institute of Elec. Engs. by Messrs. C. F. Harding and A. N. Topping. In order to reproduce as far as possible working conditions, many of the tests were carried out on the line, observations of a signal being made from a special car at varying distances, with an opposing headlight placed behind the signal.

The tests showed that the power of correctly perceiving signals was distinctly affected by the luminous haze caused by the headlight on the car. For this reason exceedingly powerful headlights proved to be undesirable ; indeed, the signals could be more easily detected with oil headlights than with the more brilliant electric arc. But what was even more striking was the effect of powerful *opposing* headlights. The "glare" from such lights very markedly interfered with the power of distinguishing distant signal lights. In addition, it was found that a "dummy" obstruction, having sufficient bulk to wreck a train, could be placed on the line without becoming visible to the driver in time to enable him to pull up if travelling at a high speed.

A specially interesting point was the investigation of so-called "phantom" green signals, which are obtained by reflection from the glass roundels of the signals when not lighted. Such phantom signals are particularly liable to be seen when the spectrum of the source in the headlight is rich in green.

* *Illum. Eng.*, London, Aug., 1910, p. 522.

The Box Integrating Photometer.

By Lancelot W. Wild.

At a meeting of the Illuminating Engineering Society on March 15th last I put the query: Is the globe form absolutely necessary for an integrating photometer and would not a rectangular box, being both easier and cheaper to make, answer the same purpose?

At the next meeting Professor Sumpner submitted a communication on this very subject, and showed that theoretically the rectangular box should be very nearly if not quite as good as a globe.

Prof. Sumpner also took the opportunity to point out two very likely sources of error in either form of photometer, namely, the error likely to be introduced by a very slight tint in the lining, and the error that may occur if the window is not perfectly diffusive. This communication was followed by a discussion in the *Journal*, in which several acknowledged authorities took part.

Prof. Ulbricht took the view that a rectangular box could not be independent of the light distribution of the source, owing to the edges of the box being further from the source than the middle of the sides. He suggested 40 per cent as a possible error in extreme cases. If, however, equality of distance is of so great importance, why is it that the source of light in the globe photometer is so commonly placed eccentrically?

Dr. Bloch agreed with Prof. Ulbricht that a rectangular box would not be free from the influence of light distribution.

Mr. J. S. Dow suggested that a rectangular box would be nearly as good as a globe if it were made large enough, and suggested that it might be made by setting apart a whole room, painted white inside, and provided with a small window which should form the test-plate of the photometer bench.

Prof. G. W. O. Howe was perhaps the most comforting, as he stated that he had set his students to make a box photometer, and, so far as had been ascertained, it gave correct results.

Prof. Sumpner in his reply to his critics admitted that the subject could not be settled theoretically. Theoretical treatment is based on the assumption that the reflecting surfaces obey the cosine law, which we all know is not strictly the case, and also fails to make due allowance for "foreign" bodies within the sphere or box.

Prof. Sumpner's theoretical treatment and Prof. Howe's comforting contribution encouraged me to try my hand at making a box for the particular purpose of testing incandescent lamps.

Accordingly I made the box. The inside dimensions are 22 in. long, 20 in. wide, and 20 in. high. The front is pierced with a circular window 2½ in. in diameter. One side is hinged and is opened for the insertion of lamps. One ½ in. hole is bored in centre of back and half-a-dozen ½ in. holes are bored in the roof. These are to take a ½ in. brass tube with lamp-holder on the end, so that the lamp can be changed from vertical to horizontal whilst still occupying the same position in the box. A number of ¼ in. holes are bored in the roof of the box to allow of a screen being suspended by a brass rod in various positions between the lamp and window. Several screens of different shapes and sizes were constructed and various materials were procured for the window.

The box stands on a bench with the photometer test-plate in a fixed position 6 in. from the window, balance being obtained by varying the distance of the comparison lamp. It was found impossible to obtain sufficient illumination of the window to permit of balance

being obtained by varying the distance of the test-plate from the window.

The first thing to settle was the lining. This must be perfectly neutral in colour, as the least tint becomes greatly exaggerated by successive reflections.

The first lining tried was ordinary white cardboard. This proved to be so very yellow as to make it very difficult to judge the balance when lamps of similar colour were compared.

I next tried white glazed paper, such as is used for printing from process blocks. This was an improvement, but was still too yellow.

I did not think it worth while to try blotting paper, as I know that, however white to start with, this very quickly yellows with age.

Finally, I lined the box with zinc, and painted it with six coats of zinc oxide ground in oil. The object of using oil in preference to gum or size was to obtain a smoother surface, which would be less likely to catch the dust from the air.

After the third coat the lining was tested for colour, and came out far too blue, due apparently to the zinc showing through the paint. The colour, however, improved with successive coats, and after the sixth coat no tint could be noticed when tested with either tungsten or carbon lamps fairly matched for colour.

The next thing to test was the effect of light distribution. For this purpose a tungsten filament lamp having a very small end-on candle-power was employed. The lamp was tried hanging vertically and then placed horizontally in the same position. I thus obtained the same total flux of light, but differently distributed. Tests were made with various screens and windows, and with the lamp and screen in various positions.

The following results were obtained :

1. 10 in. circular screen, 8 in. from front. Lamp 8 in. from back. Clear window. Test-plate sees front of screen only and no light from lamp falls directly upon this side. Apparent candle-power 3 per cent *greater* with lamp filament horizontal than when vertical.

2. Conditions as above, but window covered by thin blotting paper dipped in wax. Difference $2\frac{1}{2}$ per cent on changing over.

3. Rectangular screen, measuring 5 in. by 3 in., 8 in. from front. Lamp 8 in. from back. Waxed blotting paper in window. $1\frac{1}{2}$ per cent *more* emission with filament horizontal.

4. Conditions as above, but screen $6\frac{1}{2}$ in. from front. Same result.

5. 5×3 screen, $6\frac{1}{2}$ in. from front. Lamp 8 in. from back. Clear window. Four per cent *less* emission with filament horizontal.

6. 5×3 screen, $6\frac{1}{2}$ in. from front. Lamp 8 in. from back. Window of glass dipped in wax. Difference between vertical and horizontal filament is nil. If lamp is tilted at an angle of 45 degrees 2 per cent *less* emission is obtained. No difference could be detected on rotating the lamp suspension so that the tip pointed in turn to all the cardinal points of the compass.

Tests 1 to 4 indicate that the presence of foreign bodies is to reduce the effectiveness of the light radiating horizontally.

Test 5 indicates that when no diffusive window is employed the light radiated horizontally is too effective, due to the test-plate being directly exposed to a large portion of the back of the box.

Test 6 shows how the effect of foreign bodies may be compensated for. The semi - diffusive window allows just enough light to pass through without diffusion to compensate for the obstruction caused by the screen.

Test No. 6 also shows that the light emitted at 45 degrees is not quite fully effective. Apparently this is due to its having to travel a greater distance before reaching a reflecting surface. This is a fault of the rectangular box, which would not be shared by the globe.

In comparing incandescent lamps of ordinary construction, the variation in the ratio of horizontal candle-power to candle-power at 45 degrees is not very large, and it seems probable that the error due to the rectangular form of box would be smaller than could be detected.

If, however, one had to compare two lamps, the one with vertical filaments and the other with filaments all inclined at 45 degrees, the latter would come out about 2 per cent too low.

Whilst the tests for effect of distribution were in progress I also made tests to ascertain the best position for the lamp, so that the light emitted should not be affected by small changes of position.

With the 5 × 3 screen $6\frac{1}{2}$ in. from front and the waxed glass window no change could be detected on moving the lamp from 8 in. from back to 7 or 9 in. from back. At 10 in. from back the light was reduced by about $\frac{3}{4}$ per cent and at 11 in. by 3 per cent. It was also found that the lamp could be moved 1 in. up or down or to either side without any change being apparent. The effect of foreign bodies becomes accentuated when the lamp is placed too near to the screen or either wall.

It appears that for testing incandescent lamps a rectangular box constructed on these lines is quite practicable, and in practice is not likely to lead to error if due precautions are taken.

With the test-plate at 6 in. from the window the illumination obtained from a 16 candle-power lamp is 1·5 candle-foot, which is quite a convenient figure to work with.

Concrete Blackboards for Schools.

The clearness to those at the back of the room of the writing and diagrams chalked on the surface of a blackboard depends very much upon the material of which this surface is composed. In many large lecture theatres there will be found students at the back of the room to whom reading the particulars on the board presents difficulties. Not infrequently handwriting on the board is difficult for even a person of normal sight to distinguish under these circumstances, and this is at least partially attributable to the reflecting quality of the surface.

One defect in some slate blackboards is that the surface is too shiny, with the result that regularly reflected light shines into the eyes of the observers and obscures the chalked writing. In other cases the material is not a "dead black," but is greyish in tint, so that the contrast with the white writing is not sufficiently marked. What is really needed, apart from the proper conditions of illumination of the board, is the provision of an absolutely dead mat black material. According to a recent number of *Popular Mechanics*, concrete blackboards are being now introduced into classrooms in the United States, and are proving very effective. By this means a surface flush with the wall and of a very dead black can be secured, so that the board can be viewed quite satisfactorily from any angle, without any glare being seen.

Municipal Electric Light and Power Station in the United States.

According to *The American Gas Light Journal* there were in 1907 1,252 municipal central stations in the United States. Of these only 521 were "purely electric," but 731 were "composite," *i.e.*, engaged also in other business (such as gas supply) in addition to the supply of electrical energy.

Of the 3,462 commercial central stations nearly two-thirds were "purely electric." The fact that a relatively much greater proportion of the municipally owned central stations are "composite" is explained by the tendency of municipalities to supply gas and water as well as electricity.

High Efficiency Lamps:

Their Effect on the Cost of Light to the Central Station.

By S. E. Doane.

(Paper read before the National Electric Light Association at its Thirty-third Convention held at St. Louis, May 23-27, 1910; abbreviated.)

The extreme importance, from the standpoint of the Electricity Supply Company, of the advent of the metallic filament lamp has led to the publication of a great many papers on the subject. Mr. Doane points out how the number of papers of this kind has increased of recent years. He suggests, however, that only in a few cases has any adequate attempt been made to attack the problem on the most profitable lines, namely, on the basis of *analysis of costs*. Dr. John Hopkinson, in 1892, was the first to divide costs into "fixed" and "operating" classifications; and Mr. Doherty, in 1900, adopted the same method, and also proceeded to subdivide further the fixed costs. Practically the only statistical information on the subject, however, is that contained in the United States Census and in the reports of the various State Commissions. Mr. Doane, however, has received special assistance from the Central Station Engineers throughout the country, who have freely opened their books to him for information. A number of men on his staff have been engaged for two years in collecting and tabulating the data here presented.

In studying these questions it is first of all necessary to make certain assumptions on which further argument can be based. Mr. Doane therefore proceeds :—

First. Let us agree that our discussion is limited to the lighting load.

Second. Let us agree that in order to obtain a fair average, and to include the yearly mid-winter peak, our analysis must cover a period of at least one year.

Third. Let us agree that the average equipment in the country as a whole must be considered to be not excessive for the maximum demand, from the standpoint of a cost analysis.

Fourth. Let us agree that every item of out-go, including dividends, interest, depreciation, obsolescence, and all losses, are as much items of cost as the usual items of coal, labour, &c.

As a basis for the discussion which is to follow, I wish to present the results of a careful cost analysis of a number of Central Stations, which is summarized in Table I. In this table four separate cases, designated as "*a*," "*b*," "*c*," and "*d*," are shown, together with their weighted average.

In the following table, "*a*" represents a large Central Station giving free renewals, "*b*" represents another large Central Station operating under considerably different conditions, but also giving free renewals, "*c*" and "*d*" represent the average conditions of a number of small Central Stations. There are about 70 Central Stations in the East, represented in "*c*," and about 40 in the West in "d."

The percentage distribution of the total cost under the items "General Expense," "Distributing Expense," "Generating Expense," &c., is shown separately for each of the four cases represented in the column headed "Per Cent of Total Station Expense." Each of these items has been further analyzed and distributed by percentage under one or more of the headings as shown in the last three columns of Table I. The portion of each item charged to "Output" represents the relative proportion of the cost which

TABLE I.

CENTRAL STATION COST ANALYSIS.

Item.		Per Cent of Total Station Expense.	Per Cent Item Proportional to Output.	Demand.	Consumers.
General Expense	*a*	12.7	...	75.4	24.6
	b	14.5	...	71.0	29.0
	c	10.2	...	82.8	17.2
	d	10.9	...	80.0	20.0
	Weighted average	12.0	...	76.9	23.1
Distributing Expense	*a*	15.2	50.2	26.4	23.4
	b	9.7	44.7	21.4	33.9
	c	17.8	50.6	24.7	24.7
	d	12.8	31.8	56.9	11.3
	Weighted average	14.4	47.0	28.9	24.1
Generating Expense	*a*	13.4	80.7	19.3	...
	b	17.7	74.6	25.4	...
	c	32.1	70.3	29.7	...
	d	32.3	67.9	32.1	...
	Weighted average	23.9	72.0	28.0	...
Taxes and Insurance	*a*	8.1	...	80.0	20.0
	b	10.9	...	86.2	13.8
	c	6.8	...	85.9	14.1
	d	4.4	...	80.0	20.0
	Weighted average	7.8	...	84.0	16.0
Depreciation	*a*	11.6	...	80.0	20.0
	b	11.5	...	79.5	20.5
	c	9.0	...	85.9	14.1
	d	6.0	...	80.0	20.0
	Weighted average	9.8	...	81.8	18.2
Interest and Dividends	*a*	39.0	13.1	68.1	18.8
	b	35.7	27.2	55.1	17.7
	c	24.1	26.4	61.4	12.2
	d	33.6	8.9	73.7	17.4
	Weighted average	32.1	19.7	63.7	16.6
Total	*a*	100.0	23.5	58.5	18.0
	b	100.0	27.2	55.1	17.7
	c	100.0	37.9	50.8	11.3
	d	100.0	28.9	59.5	11.5
	Weighted average	100.0	30.3	55.1	14.6

"*a*" Represents a large Central Station giving free renewals.
"*b*" Represents a large Central Station giving free renewals.
"*c*" Represents the average of about 70 Stations in the East.
"*d*" Represents the average of about 40 Stations in the West.

depends upon the number of kw.-hrs. generated. The portion charged to "Demand" represents the relative proportion of the cost, which depends upon the capacity of the station, which in turn depends upon the "Demand." The portion charged to "Consumers" represents the relative proportion of the cost, which depends upon the number of consumers connected and served.

In the foregoing table the fixed costs have been divided into two subdivisions, one of which we call the "Demand Cost," the other the "Consumer's Cost." After a proper allowance for the diversity factor, this demand cost, expressed as a fixed charge per kw. of maximum demand, indicates, in our judgment, the amount which would properly cover the cost involved in supplying the maximum demand. This cost is one of the two components which go to make up the total fixed cost. It may be claimed that this demand cost is not the same per kw. of maximum demand for all sizes and classes of customers. The advocates of this view tend to increase the demand cost per kw. of demand to the small customer, consequently any concession

to this view magnifies this feature of the cost analysis for customers of the average size, and smaller customers.

Mr. Doane then proceeds to mention a few examples of the doubtful points in classification which occur in connexion with the allocation of the "Demand" and the "Consumer's" cost. There are, of course, many such vexed questions of detail to consider, but they are usually not of sufficient magnitude to affect the broad deductions contained in the paper. He proceeds :—

As we go further into this subject, the extreme importance of the consumer's cost, especially in the case of the small consumer, must be conceded, and, consequently, we have distributed these costs with extreme care.

We believe that the percentages we give in the table are conservative, and that they indicate, at least, the nominal cost at which a new customer can be added to the system on the present basis.

We must concede that every customer, no matter how small, must have a pair of wires and necessary poles, fixtures, conduits, &c., to bring the wires to his premises. We must concede that he must have a meter or some current limiting device, and that he must demand some attention in the way of meter reading, inspection, billing, &c. Consequently, we must all agree that any given customer, as pointed out by Mr. Doherty, costs the Central Station some definite minimum amount per year or average month, even though it may be that he uses no current whatever.

The three divisions of costs indicated above are commonly referred to as the "Demand Cost," the "Consumer's Cost," and the "Output Cost," and in analyzing costs of rendering service and energy to individual consumers are conveniently expressed as unit costs in terms of kw. of maximum demand (or equivalent unit, such as floor space illuminated or light delivered), the customer, and the kw.-hr. respectively.

The two large Central Stations mentioned in items "*a*" and "*b*" of the table have rather large average customers. Their average customers consume about 3·6 and 3·2 kw. respectively at the time of maximum demand.

The Massachusetts Commission report would indicate that the average customer of Massachusetts consumes about 1·5 kw. at the time of maximum demand. The Wisconsin Commission report would indicate 1·8 kw. as the average maximum demand. Our observations would tend to confirm these figures, and our further analysis indicates that 11 per cent is about the right load factor to apply to the average consumer. We have also assumed that a load factor of 7 per cent may represent a short hour user, and a load factor of 20 per cent a long hour consumer. The term "load factor" in this connexion is used to mean the percentage which the actual kw.-hrs. consumed in a year bears to the total number of hours in a year, namely, 8,760 times the maximum demand.

Let us now discuss the effect of the high efficiency lamps on the cost of serving the Central Station average customer, after which we will consider the effect of the high efficiency lamps in serving larger and smaller customers with larger and smaller load factors.

With the figures in the foregoing portion of this paper as a basis, we have plotted some diagrams which show the effect of the adoption of the high efficiency lamps by a customer of 1·6 kw. maximum demand and 11 per cent load factor. (See Fig. 1.)

We have chosen to graphically represent the relative distribution of the three items of cost entering into the cost of serving the individual consumer under various conditions by rectangles divided into three parts, which show, according to the relative size of the parts, the magnitude of the several items of cost.

The first single rectangle in Fig. 1 represents the cost of the *average consumer*, which we have assumed to have 1·6 kw. maximum demand, and a load factor of 11 per cent. Let us assume now for a moment that this average customer changed to some one of three high efficiency lamps, and obtained the same amount of light as before. The result is shown in the middle group

of diagrams in which the longest parallelogram shows the effect on the cost of the adoption of the Gem lamp, the next the Tantalum lamp, and the third the high-class Tungsten filament lamp. It will be noted that, without adding any new customers, the Central Station is unable to reduce the demand cost, which is charged against the customer, and that the sole reduction in cost is therefore due to the reduction in the number of kw.-hrs. required to produce the same amount of light in a more efficient manner.

In the illustration the immediate reduction of cost due to the adoption of the Gem lamp is 8·7 per cent, the reduction due to the adoption of the Tantalum lamps is 13 per cent, and the reduction due to the adoption of the high-class Tungsten filament lamp is 19·5 per cent. It is evident, therefore, that even though the consumer's consumption of energy is reduced two-thirds, the cost of light is only reduced by two-thirds of that portion of the cost which varies with the kw.-hrs. The total cost reduction is, therefore, only about 20 per cent instead of 60 per cent.

In all these assumptions the renewal cost of the lamp has not been considered to have increased, since it is believed that the general practice of Central Stations everywhere is to charge the difference between the cost

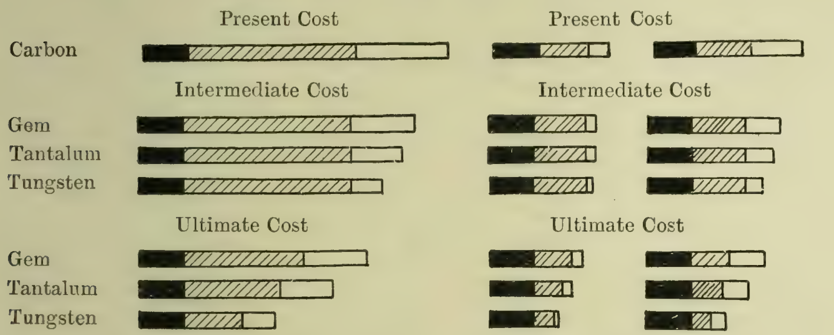


FIG. 1. Consumer having 1·6 K.W. max. demand and 11 p.c. load factor.

FIG. 2. Consumer having 0·5 K.W. max. demand and 7 p.c. load factor.

FIG. 3. Consumer having 0·5 K.W. max. demand and 20 p.c. load factor.

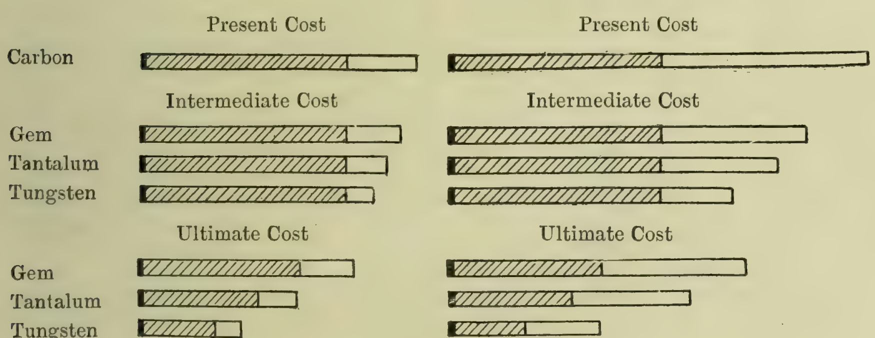
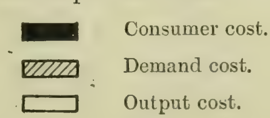


FIG. 4. Consumer having 20 K.W. max. demand and 7 p.c. load factor.

FIG. 5. Consumer having 20 K.W. max. demand and 20 p.c. load factor.

RELATIVE COST OF PRODUCING A GIVEN AMOUNT OF LIGHT.



of the carbon lamp and high efficiency lamps to the customers, and as this cost of light is being considered from the standpoint of the Central Station, the cost of renewal does not figure therein.

In the same diagram the lowest group composed of the three short rectangles shows what happens when the station has added enough customers to entirely utilize its output after every customer has been changed to high efficiency lamps. This shows that by the adoption of the high-class Tungsten filament lamp the cost of producing light for the average consumer is reduced 55 per cent.

A tabular expression of these diagrams is given later in a complete summary.

The total cost to the Station for the individual customer can be determined when the maximum demand and the load factor are known. Assuming a customer of small size, having, we will say, 0·5 kw. as maximum demand, let us analyze the cost conditions with both short and long hour use as represented by load factors of 7 per cent and 20 per cent respectively. The results are indicated in Figures 2 and 3. I may say that if our assumption of 1·6 kw. as the average demand of a customer is wrong, this quantity 0·5 kw. is also wrong numerically, but still illustrates correctly the effect on the cost of serving a customer of one-third the average size, whatever that average size may be.

We find that when such a customer is a short hour user that the cost of kw.-hrs. is only about 16 per cent of the total cost when the customer uses carbon lamps, and is only about 6 per cent of the total cost when the customer uses the highest efficiency lamp; and we further develope the astonishing fact that even when such a customer receives the maximum benefit of this new lamp by addition of enough customers to employ the entire capacity of the Central Station, when utilized with high efficiency lamps the cost of actual energy consumed is still only about 10 per cent of the total cost of carrying such a customer. Further reference to the comparative values shows that even in the case of a long hour user having the same maximum demand the kw.-hrs. consumed cost the Central Station but a very small part of the total cost for the customer. Most of the cost in the case of the small consumer is involved in supplying service of one character or another. These diagrams indicate that the high efficiency lamp materially reduces the cost of producing a given amount of light for such a customer, but that in the case of the average small customer the reduction in cost is in no sense comparable with the reduction in energy required for a given quantity of light.

Reference to the diagram shows further that the cost of supplying current is a small percentage of the total cost, and a reduction of a small percentage in that cost gives almost no saving in cost whatever. If we succeed in fully loading up the station with lamps of higher efficiencies, the cost of the smaller customers will be reduced to 82, 73, and 60 per cent of the present cost with gem, tantalum, and tungsten filament lamps respectively.

Figures 4 and 5, representing a large consumer, show a very different situation, as it will be observed that the consumer's cost is an insignificant proportion of the whole. The first reduction in cost due to the use of high efficiency lamps by a short hour customer, of this size, is only about 15 per cent when such a customer uses the highest efficiency lamp most advantageously. A summary of the foregoing diagrams will follow in the continuation of this paper.

(*To be continued.*)

School Lighting.

(Notes on a lecture recently delivered by Dr. N. Bishop Harman before the Public Health Dept. of University College, London.)

An interesting lecture dealing with some aspects of the above subject was recently delivered before the Public Health Department of University College by Dr. N. Bishop Harman, and is referred to in a recent number of *School Hygiene.*

The environment of the greatest importance in a school, he said, is light, though, to judge from the conditions in some schools visited, this is not so generally recognized as might be supposed.

Arrangement of Windows.

One vital point as affects daylight illumination is the extent and position of the windows. Now windows can, as a rule, only be placed along one side of a room in any large building, and therefore shadows can hardly be avoided, (though, it may be added, their intensity depends very much on whether the walls are light or dark in tint). In this connexion Dr. Harman remarked: "Light from behind is absurd—the child sits in its own light. Light from the front is bad—the child is dazzled by the glare. Light from the right-hand side is poor—shadows are cast on the writing hand. There remains only the left hand—and light therefrom is at its best."

It is therefore desirable that the left-hand wall of the classroom should carry one large window extending from five feet above the floor to the clear level of the ceiling. Sunblinds should be of cream holland material, and not only the desks but the blackboards and charts in the teacher's part of the room should be well lighted.

Artificial Lighting.

Artificial illumination is rarely as satisfactory, from the hygienic standpoint, as that prevailing in the daytime. So far as possible, therefore, close work such as sewing should be stopped when daylight fails. A common fault in artificial lighting is the crowding of the lights near together in the centre of the room so that the distribution of light is very imperfect. Some desks receive more light than they require; others receive too little. Moreover, the light will strike many of the desks from the wrong direction, and some of the children will nearly always be found to be working in their own shadows.

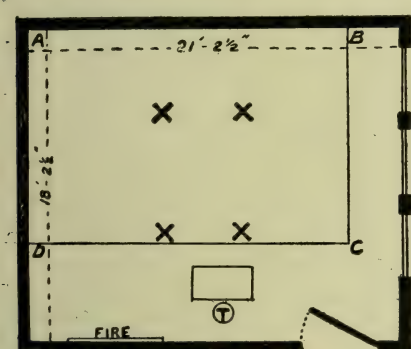


Fig. 1.

Plan of room ill-arranged. Natural light is to left, but is separated from desk area A B C D by gangway.

Artificial lights are hung at X X X X and are too close together.

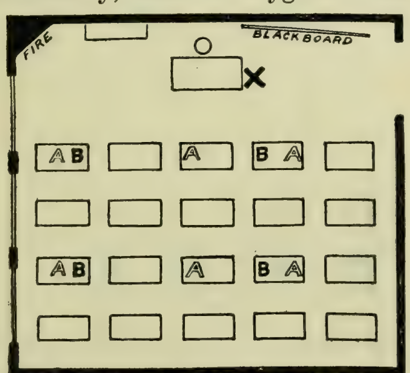


Fig. 2.

Plan of well-arranged room for 40 children. Left window light. Incandescent gas-light points at A for infants; at B for higher standards; at X a point of light, with opaque shield to screen it from children, for illumination of teacher's desk and blackboard.

For example, Fig. 1 shows a room in which this mistake has been made, while Fig. 2 shows an arrangement which Dr. Harman considers much more satisfactory, as it not only serves to illuminate the desks adequately, but also provides special lighting of the blackboard. The value of shades and reflectors, as a means of diffusing and distributing the light more efficiently, deserves particular mention.

"*Acuteness of Vision*" *as a Photometric Test.*

As a rough method of testing whether the illumination is sufficient Dr. Harman has used a chart consisting of a card on which is marked out a series of dots of different sizes as in Fig. 3. It should be possible to see the row of smallest dots, as a distinct series, at a distance of six metres. These dots are made to the size of Snellen's type D = 6, and the

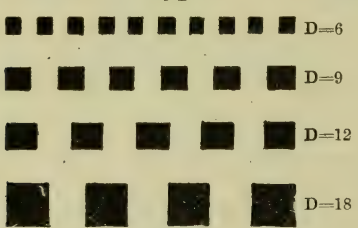


FIG. 3.

space between each black dot should be equal to the space covered by it. Other rows of dots of larger size corresponding to D = 9, 12, 18, &c., are provided. In any schoolroom it is desirable that the row D=6 should be clearly seen at the prescribed distance. If the row 18 is not clearly distinguishable, then the illumination is undoubtedly insufficient. An illumination of 10 metre-candles is the minimum permissible illumination.

Illuminated Detail and Eyesight.

Special emphasis should also be placed on the necessity for good bold type. Hard white paper, free from excessive shine, and heavy Clarendon type are desirable. Small type must be avoided at all costs. It tries both the eyes and the brain. However, close vision is always apt to be trying to small children. Dr. Harman declares that for the younger classes he would far rather use well-lighted blackboards and no books at all. In any case the main essentials in any class are "a good teacher first and a few good books a long way second."

Again, quite apart from the physiological effect of the examination of fine detail on the eyesight, there is the psychological aspect of the matter to be considered. Young children are not interested in, or capable of appreciating, fine distinctions or minute detail. The child's ideas are simple. Pictures should therefore be of a correspondingly plain and simple character without "niggling" masses of fine lines. In writing, broad penmanship and strength of line are desirable for the same reasons. Spidery writing and fine pens are objectionable.

Testing the Fatigue of Vision.

One very interesting point touched upon by Dr. Harman in this lecture was the testing of eye-fatigue. We should find it a much easier matter to determine when the lighting conditions in a room were objectionable in some respect if we had some ready means of deciding when fatigue had begun to occur. There have been efforts to examine this matter by tests of visual acuity and range of accommodation at intervals, by setting sums, mental arithmetic, &c. But as a rule such tests do not yield sufficiently definite results. It is always possible by a special effort to counteract the effect of fatigue.

Dr. Harman, however, claims to have found a specially sensitive and serviceable test based on the principle of binocular vision. The capacity for binocular vision varies very greatly in different individuals. In some cases it only just exists, so that under unusual conditions of work or strain a temporary squint appears. Something of this sort may happen when a child complains that "the print goes misty." Therefore if we could measure the capacity or desire for binocular vision by simple means, it might afford us a satisfactory criterion as to the degree of fatigue experienced.

The principle consists in viewing a card, on which some detail is inscribed, through a suitable aperture, the arrangement being shown in Fig. 4. The dimensions of the aperture are such

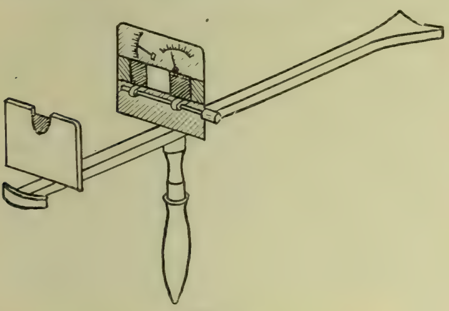


FIG. 4.

that the middle portion of the card is seen by binocular vision and the two lateral portions by the right and left eye respectively, as shown diagrammatically in Fig. 5. Experiment shows that different people require different breadths of this middle band to keep their eyes on an even balance, and that this width varies according to their physical alertness. The middle band, in fact, constitutes an "ocular poise," and may be regarded as a criterion of fatigue. In making a test, therefore, one measures the extent of this band when the subject is fresh

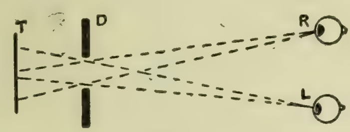


FIG. 5.

and then again when he is to some extent tired; the variation in this figure indicates how far fatigue has proceeded. This, at any rate, seems to be the method of test prescribed by Dr. Harman, and it will be interesting to see how far it can be used with effect in practice, in connexion with problems of illumination.

The Sensitiveness of Different Eyes to Ultra-Violet Light.

THE eye seems to be able to perceive only a narrow range—about an octave—of visible radiation. This has generally been ascribed to the fact that the receiving apparatus, like a well-tuned instrument in wireless telegraphy, can only respond appreciably to a certain range of frequency. The maximum sensitiveness seems to lie about the middle of the visible spectrum.

But there is another phenomenon which is not without influence in this direction, and this was recently referred to by M. Gariel in a paper before the Société Francaise d'Ophtalmologie. It is suggested that our eyes could perceive a more extended range of vibrations if such radiation could reach the retina. But it appears that the infra-red and ultra-violet rays are very strongly absorbed by the optical system of the eye on their way. Many observers have found that the eye-lens fluoresces under the action of ultra-violet rays, and have adduced this as evidence that this kind of radiation is absorbed. Stockhausen has suggested that cataract might be a gradual result of prolonged exposure to ultra-violet rays in this way.

An interesting experiment in support of this view is described by M. Gariel. An arc-light was placed behind a special screen, formed by depositing a very fine film of silver on glass. A film of this kind has the property of permitting ultra-violet rays to pass, but completely absorbing the visible light. Ordinary people, therefore, were naturally unable to see the arc through this screen.

But there were certain persons whose eyes had been subjected to an operation for cataract, involving the removal of the crystalline lens of the eye, and who could see an image of the arc quite distinctly. It may be noted that it was not the incandescent tips of the carbons, but the arc-vapour itself (which is believed to be the chief source of ultra-violet light in the arc) that

they saw. Apparently, therefore, the inability of people with normal eyes to perceive ultra-violet light may be partially due to the fact that their eyelens absorbs it.

Another interesting experiment has since been made in support of this hypothesis. Observers have noted that a distinct change in colouration of the eyelens often takes place during life, rendering the eye of an adult less susceptible to the effects of ultra-violet light than that of a child. It has been suggested that this gradual colouration is in the nature of a protection. One might therefore have expected that young children would have seen the arc under the conditions named above when an adult would fail to do so, and Dr. Gayet is said to have found this to be the case.

An experiment of Dr. Stockhausen and Schanz on this point, the results of which are shown in the accompanying figure, is also striking. In the upper diagram some photographs of spectra of the light after it has passed through the cornea of the eye only are reproduced. The spectra below, taken with exactly similar exposures, represent the light which is transmitted after passing through the crystalline lens of a lady sixty years old.

The marked extinction of the ultra-violet portion of the spectrum in this latter case is very striking.

These demonstrations of the absorption of ultra-violet by the eye-lens are of considerable interest in view of the suggestion that these rays are responsible for cataract, and specially so in an account of the suggestions that have been brought forward to the effect that the ultra-violet light present in some artificial illuminants may be prejudicial to eyesight.

Time of Exposure

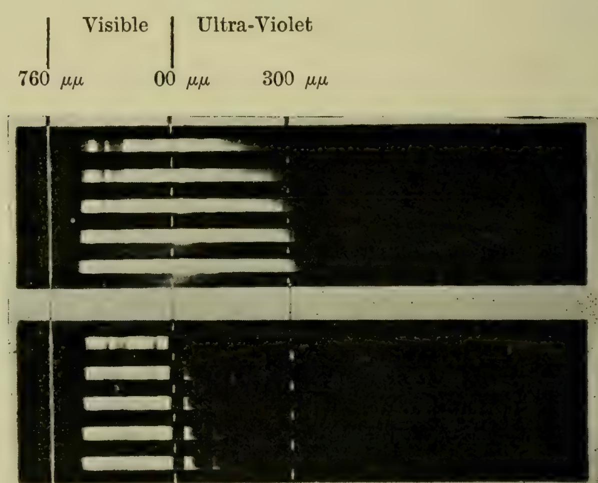


FIG. 1. 2 seconds, 5 ,, 10 ,, 20 ,, 40 ,, — Cornea of lady 60 years old.

FIG. 2. 2 seconds, 5 ,, 10 ,, 20 ,, 40 ,, — Completely transparent lens from the eye of the same lady.

The Emissivities of Incandescent Lamps Considered from the Standpoint of their Reflectivities.

By W. W. Coblentz.

In previous communications in this journal the writer has called attention to the fact that all the pure metals thus far examined, covering the whole range of the Mendeljeff series, have the common property of a low reflecting power in the ultra-violet and in the visible spectrum, which rises abruptly to very high values beyond 1·5 to 2μ in the infra red, and that it is therefore not unreasonable to assume the unexamined metals such as tungsten and osmium to have this same property. In the regions of the visible spectrum where the reflectivity is low the emissivity must be high, and in the infra red the emissivity must be low because the reflectivity is high. Or to express it more crudely, those frequencies which can enter the metal the most easily can get out of it just as easily, while the slow frequencies encounter opposition in their entrance and in their exit.

It is difficult to show experimentally this selective emission in other than coloured metals (*e.g.*, gold and copper) by means of emission spectra, and since the emissivity in the short wave-lengths appears to have only a small temperature coefficient, it is possible to gain some knowledge of the emissivity of the metal at high temperatures by determining its reflectivity at low temperatures. This will give a positive qualitative proof of the much-discussed and much-overworked application of "selectivity" to explain the high luminous efficiency of metal filament lamps.

While it is very quieting to the mind to assume that tungsten and other metal filaments must have optical properties similar to those of the metals already investigated, it does not leave the assurance which comes from subjecting the question to experiment. In a previous article* the writer expressed the regret that up to that time (after searching for almost two years) he had been unable to procure mirrors of these metals with which to test the aforesaid conclusions. Immediately thereafter the opportunity was granted to examine these new metals, and the data is included herewith for comparison with the previous work.

Through the kind interest taken in preparing the material by the General Electric Co., and by Siemens & Halske, an opportunity was presented to examine large samples of these metals in a high state of purity. The reflecting surfaces were usually 5×17 mm. A regulus of pure tantalum was also sent me by Dr. Von Wartenberg, who had determined its optical constants in the visible spectrum. The unknown metal was compared spectrobolometrically with a plane silver mirror of known reflectivity, and from this the absolute reflectivity was obtained.

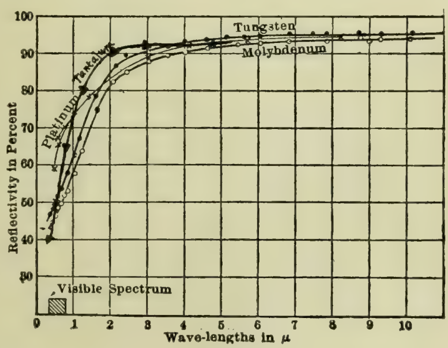


Fig. 1.

As will be noticed in the appended illustrations, the previous assumptions of a low reflectivity (and hence high

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* *Illum. Eng.*, vol. iii., p. 87, 1910.

emissivity) in the visible spectrum has been verified to a degree far beyond expectation. For example, the emissivity of tungsten is almost 50 p.c. in the visible spectrum, while in the infra red it is only from 5 to 10 p.c. that of the ideal radiator or "black body."

In Fig. 1 it will be noticed that the reflectivity of tungsten rises abruptly from a low value of 50 p.c. in the yellow to 89 p.c. at 2·5 μ, beyond which point it increases gradually to 96 p.c. at 10μ. This is a characteristic of pure metals.

Hagen and Rubens* have shown that for long waves (greater than 12 μ) the absorption (100 – reflectivity) of a metal may be computed from its electrical conductivity by means of the formula $100-R=\frac{36\cdot5}{\sqrt{C\lambda}}$ where R is the observed reflecting power, C is the reciprocal of the resistance in ohms of a conductor 1 meter long and 1 sq. mm. in cross

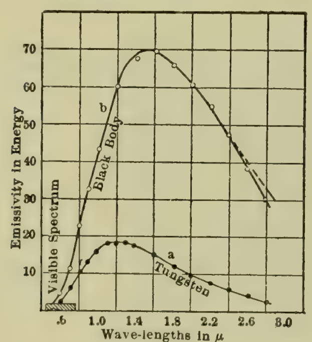


FIG. 2.

section, and λ=wave length in μ=·001 mm. From the specific resistance (·0000063 at 21·5° C.) of this sample of tungsten the computed reflectivity at 12μ is 97·3 p.c., while the value obtained by extrapolation is 96·3 p.c. This is in closer agreement than is to be expected from the difficulty in making observations in the extreme infra red, and from the small size of the mirror. The reflectivity is practically the same as platinum (except in the visible spectrum), from which it follows that in a previous investigation of the radiation constants of metals it was permissible to assume that the same emissivity law obtains in tungsten and platinum.

In Fig. 2, curve *a*, is given the spectral energy curve of a new 110 volt 32 c.-p. tungsten lamp when on normal operation of 55 watts. The maximum emission occurs at $\lambda_{max.}=1\cdot225\mu$. Using the $\lambda_{max.}$ T=2620 of platinum and the $\lambda_{max.}=1\cdot225\mu$ of tungsten, the operating temperature is 1,870° C. From the observed radiation curve *a*, Fig. 2, we can obtain the equivalent black body curve *b* at the same temperature by dividing the observed emissivities by the absorptivities (100 – reflectivity) of tungsten given in Fig. 1. The maximum emission lies at about 1.55 μ from which the computed temperature (using $\lambda_{max.}$ T = 2940) is about 1,760° C. It therefore appears that the "normal" temperature of the tungsten lamp is of the order of 1,800 to 1,850° C.

The reflectivity of molybdenum, Fig. 1, is slightly lower than tungsten, being 46 p.c. in the yellow and rising abruptly to 85 p.c. at 2·5μ, beyond which the reflectivity gradually increases to 95 p.c. at 10μ. The reflectivity curves of molybdenum and tungsten are so nearly alike that from a consideration of their emissivities (100 —reflectivity) there seems to be no great choice in the use of these two metals in incandescent lamps. On the other hand, from a consideration of their physical properties the molybdenum filament would be the preferable because of its toughness and its ductility in contrast with tungsten, which is very brittle. Their melting points are high, and it is principally a question of overcoming certain physical weaknesses in the molybdenum filament in order to make it practical.

The equality in the reflectivity curves show that at the same temperatures their emissivities, and hence their efficiencies, must be practically the same. It therefore remains to be seen whether the molybdenum will admit of an operating temperature as high as that which obtains in the tungsten filament.

The reflectivity curve of a highly polished sample of Siberian graphite is shown in Fig. 3. The reflecting power rises gradually from 23 p.c. in the visible spectrum to 60 p.c. at 10μ.

* Hagen & Rubens, *Ann. der Phys.* (4) 11, p. 873, 1903.

From this low reflectivity at 1 to 2μ there results a high emissivity, hence the graphitized carbon filament cannot have the same luminous efficiency as the tungsten lamp at the same temperature, although it has the higher emissivity in the visible spectrum.

The reflectivity curve, Fig. 3, of a sample of supposedly pure tantalum is lower even than graphite in the visible spectrum. There is no indication of an approach to a high and constant reflectivity in the infra red, such as obtains in pure metals (see Fig. 1). The reflection spectrum of this sample of tantalum, which was supposed to be

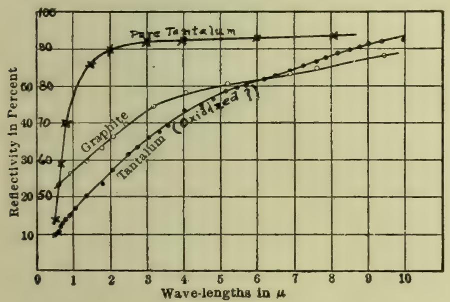


FIG. 3.

pure, has the characteristic of an impure metal or an alloy. Under the microscope the sample appeared flawless, so that the low reflectivity cannot be explained on the hypothesis of roughness and scattering of the light. This low reflectivity in the visible spectrum produces a high emissivity, but contrary to the properties of pure metals, *e.g.* platinum and tungsten, the reflectivity continues low (emissivity high) in the infra red, which lowers the luminous efficiency. The normal temperature of a tantalum lamp is not much below that of tungsten, and hence its low efficiency as compared with tungsten is to be sought for in its low reflectivity (high emissivity) in the infra red. On the efficiency basis the tantalum filament must be classified with graphite (a non-metal), which is an anomalous classification. However, the reflectivity curves and the previously observed radiation constants (total radiation; tantalum proportional to the 5·3 power and graphitized carbon proportional to the 5·1 power of the temperature) show that this classification is consistent.

The optical behaviour of the sample of tantalum examined, and its close resemblance to the lamp filaments and to some thin strips of this metal which the writer has examined, makes it of interest to learn whether the wire in the incandescent lamp is a pure metal free from carbide. Tantalum filaments are very black and nonmetallic as compared with tungsten and osmium. In fact, an ordinary tantalum filament appears darker than the mirror examined. That this sample was no doubt impure will be noticed in Figs. 1 and 3, which give the reflecting power of a regulus of pure tantalum kindly sent me by Dr. Von Wartenberg.*

The mirror surface was highly polished but it was small (3×5 mm.), which did not admit high accuracy in determining the absolute value of the reflectivities. However, the relative values for different spectral regions were easily determined; and this is the question of real interest. The reflectivity of this sample of tantalum is even more remarkable than tungsten, rising abruptly from a low value of 45 p.c. in the yellow to 90 p.c. at 2μ (Wo=85 p.c.), beyond which point a fairly constant value is approached. In this respect it compares with silver and zinc, the reflectivities of which rise even more abruptly from the visible to the infra red. This shows that pure tantalum is more selective than tungsten in the visible spectrum, and that a lamp filament of the pure metal will be at least as efficient, if not more efficient, than tungsten at the same temperature. The metallic lustre of such a filament will appear almost as bright as tungsten. The present filaments are very much darker than tungsten. The problem is to keep the filament brighter; but by this is not meant merely a high polish. So long as the porosity is not of the order of a wave-length of light, the question of "blackening" the radiation by successive reflection within

* *Wartenberg. Verh. Phys. Gesell.*, 12, p. 105, 1910.

the cavities is unimportant. But it may be observed that the avoidance of any contamination of the surface which changes the optical constants (refractive index and absorption coefficient) from that of the pure metal is of the greatest importance, as illustrated in these two samples of tantalum.

It is of interest to summarize briefly the facts gained from a consideration of the various forms of radiators described in previous papers. In the high potential spark discharge we have noticed that the maximum of the emitted energy lies in the ultra-violet, and hence is useless as an illuminant. On the other hand, solid radiators emit a preponderating amount of infra red radiation, and are therefore equally inefficient as an illuminant. The metallic vapours in the carbon have but little energy outside of the visible spectrum, and hence are the most efficient illuminants now available.

The metal filament incandescent lamp will be used in spite of its secondary position in the scale of luminous efficiency, and hence it is of interest to notice the characteristics of the various metals used in these lamps. The ideal solid illuminant must withstand a high operating temperature, and must emit selectively an enormous amount of energy in the visible spectrum, with but little infra red radiation. How thoroughly handicapped we are in the selection of such an illuminant is at once evident. From Figs. 1 and 2 it will be noticed that pure tantalum would fulfil the aforesaid conditions ; but our present filaments of tantalum are a dark coloured crystalline mass scarcely more efficient than graphitized carbon. The lustre of a pure metal filament of tantalum would be as bright as that of tungsten, which is not true of the present material. The problem is to draw the wire without contaminating it with a lubricant. Oil seems to adhere to tantalum with great tenacity. From Fig. 1 it will be noticed that after tantalum the next in order of efficiency is tungsten. This metal withstands the requisite high operating temperature, and it does not vaporize readily ; but it is brittle.

Since the reflectivity of molybdenum is practically the same as that of tungsten, its luminous efficiency must be of the same order as tungsten when operated at the same temperature. It is tough and ductile, hence commends itself as a substitute for tungsten ; but evaporation and other defects seem to debar this metal from usage, at least for the present. We thus find that where we gain one advantage we lose another. One may well ask, " What shall be tried next ? "

Bizarre Types of Gas Fixtures and Illuminated Hands.

A CONTRIBUTOR to *The American Gas Light Journal* refers to the demand for unusual and striking devices in connexion with gas fixtures. The liking for peculiar and ingenious devices of this kind is of ancient origin. For instance, the old kings of ancient peoples modelled reptiles, beasts, and birds out of stone, and arranged for inflammable vapours to be emitted from their jaws so that they appeared to be breathing forth flame.

An illustration of a kindred device is afforded by the modern use of hands cast in glass or metal, and provided with ducts through which the gas can pass. In this way the appearance of an illuminated hand holding a torch from which a gas flame issues can readily be produced. Sometimes a variation is introduced by arranging for the hand to hold a miniature flower, or even for the tips of the fingers to shoot forth small flames. Devices of this kind are said to have been found specially convenient for direction signs and notices.

The Standardization of Gas Supply.

By an Engineering Correspondent.

Any rational proposals, introduced with a view to effecting the standardization of one or other system of lighting, deserves the sympathetic attention of all who are interested in the manifold problems of illuminating engineering, inasmuch as the success of such proposals may unquestionably be regarded as a step towards uniformity in the wider field of illumination where rival systems are concerned.

It is for this reason, quite apart from the admitted merits of their proposals, that the three Standard Burner Bills promoted by certain gas companies, which have just successfully emerged from the careful and patient consideration of two Parliamentary Committees, and which are now assured a safe and uninterrupted passage to the Statute book, assume a general interest and importance. Promoted by eight companies, the three Bills, which were practically alike in their object, dealt with the standard burner used in testing the illuminating power of the gas supplied by the companies concerned, and may be said to be an inevitable development in the transition from the use of the flat flame burner to the incandescent mantle. The duty of prescribing what burner should be used for testing the illuminating power of gas was imposed, by the London Gas Act of 1868, upon the Metropolitan Gas Referees—a body established under that Act—and it was enacted that the burner "shall be such as shall be most suitable for obtaining from the gas the greatest amount of light and be practicable for use by the consumer." At that time, the Metropolitan Companies were supplying 16 c.-p. gas, and the burner prescribed was the No. 1 London Argand, the invention of Mr. William Sugg. During the forty years which have elapsed since then, considerable improvements have been made in the manufacture of gas, and the defects of the standard burner became increasingly manifest in the course of time. It was not generally known, or sufficiently understood at the time of the adoption of the burner, that a burner that is most suitable for testing 16 candle-power gas is not suitable for testing a higher quality of gas, and that, consequently, instead of bringing out the full amount of light as Parliament had intended, the standard burner, in the process of testing, destroyed or neutralized a certain amount of light. It was publicly stated many years ago by Prof. Harcourt, as an objection to the No. 1 Argand burner, that it exaggerated the deficiencies in the gas—for instance, to get a gas which showed 14 candles with the No. 1 burner it was necessary to manufacture not 14, but 15 or 15½ candles—and further attention was directed to the obvious injustice of this by Mr. Charles Hunt as far back as 1870.

It is important to bear in mind the fact that the No. 1 burner was constructed for the particular quality of gas made at the time of its invention. In those days gas was distilled from coal at a comparatively low temperature, and a very low yield of gas was the result. The flame from the burner rose almost to the top of the chimney, and very nearly filled the chimney itself. As gas distillation was conducted on a more scientific basis, it was seen that the yield of gas considered satisfactory in those days was very uneconomical—a higher temperature was obtained, and a greater volume of gas distilled from the coal. The gas distilled with the higher temperature had not a higher proportion of hydrogen, and the flame from it was very low indeed. In one case, the flame almost filled the chimney; if a flame which was shorter was used, a much larger volume of air would rush upwards, with the consequence that the gas became overburdened.

One of the defects of the burner was that too much air was admitted and luminosity was destroyed; therefore, as has already been suggested, instead of indicating the true luminosity of the gas, the burner destroyed it.

By the year 1891 the defects of the burner had become so glaring that the South Metropolitan Gas Company offered to bear the entire cost of an independent committee to undertake an investigation if the Board of Trade would appoint one. The interest in the question increased throughout the country, and in 1893 a deputation on the subject waited upon the Committee from the Institution of Gas Engineers. Prof. Harcourt, the Senior Metropolitan Gas Referee, was fully aware of the defects of the burner, and he publicly stated that by its use "any deficiencies in the gas were greatly exaggerated." The Referees endeavoured to get over its defects by using the burner regardless of the quantity of gas being consumed in it, and this method received Parliamentary sanction in 1900. The Act said the gas was to be burnt in the burner at the rate of 5 cubic feet per hour, and the Referees proposed to get over this difficulty by saying "you shall burn it at such a rate as will give a light of 16 candles." The 16-candle flame was much more nearly the size of the flame than was produced from the gas made by the burner invented, and the amount of air passing through between the flame and the chimney was more nearly in accord with the burner. The Referees then said: "Do not burn your gas at 5 feet an hour, but at whatever rate is required to make a 16-candle flame, and when you have done that, by rule-of-three sum, supposing the rate were 4 ft. for 16 candles, 5 ft. would give 20." This was legalized in 1900. Five years later the matter was reopened, when the question arose as to what was the use of having a method of testing a gas the object of which was to tell the consumer what he was getting, when he had not the least idea of what was going through the burner. It was then said that the only proper way of testing the gas, in order to tell the consumer what he was really getting, was to pass it through at the 5 ft. rate. The matter was thrashed out at great length before a Committee of the House of Lords, which decided that the 5 ft. rate should be reinstated. But, the Committee added, "in making your test, you shall have a burner which is so arranged that the air supply can be regulated. As a result of this recommendation, Mr. Charles Carpenter, the Chairman of the South Metropolitan Gas Co., invented the No. 2 "Metropolitan" Argand, which was provided with a chimney just in the same way as the No. 1. The difference between the burners is that underneath the No. 2 there is a shutter, which is moved up and down in the same way that the wick of a lamp is turned up and down. Having adjusted the 5 ft. rate, the shutter is turned up or down to admit sufficient air into the orifice below the burner to burn the gas with a proper light inside the chimney.

The case in favour of the Bills as presented before the Committee was based substantially upon the foregoing facts, and the evidence addressed by various witnesses went to show that the use of the No. 2 burner would give to the consumer a more constant quality of gas, and would enable him to obtain better efficiency from the incandescent burners commonly in use. The alternative proposed by the opponents of the Bill was the retention of the present test burners, on the ground that any change would inflict some financial disadvantage upon the consumers of gas. In the event of the change of burner being granted, the opponents suggested the raising of the nominal candle-power, or the bestowal upon the consumers of some definite monetary consideration as compensation for the hypothetical losses they would sustain. The Committee, which consisted of Sir Henry Kimber (Chairman), Mr. A. G. C. Harvey, Mr. Baldwin, and Mr. F. W. S. McLaren unanimously decided in favour of all three Bills. This decision was arrived at after a patient and impartial hearing of all sides, and a critical examination of all contentions. The plea for compensation put forward by

the opponents of the Bills was effectively disposed of by Sir Henry Kimber, who said: "The burners hitherto in use have been defective. The burner proposed to be established as the standard burner is, if not perfect, yet as perfect as is at present known for achieving the object of Parliament in giving what Parliament certainly intended to give—that is, a light equal to the light of so many candles." Sir Henry added that the Committee were unable "to recognise that the fact of the burner which was supposed to be perfect, and has been found to be imperfect—having perhaps done a wrong to somebody in practice—gives any right to compensation further than the legislation applicable to gas companies will automatically give."

The No. 2 burner is a great improvement upon its predecessor, as it will bring about uniformity in the method of testing gas. This is of the greatest possible importance to the industry, to the consumer, and to the manufacturer of gas plant; for the adoption of this burner of a certain definite consumption will convey to the simplest mind a clear understanding as to what the value of the gas is, and it will give to manufacturers of gas plant the power to standardize their apparatus, with resultant economies in the cost of production.

A. C.

Central Suspension of Gas Lamps in Cannon Street.

We note that an interesting experiment is shortly to be carried out in Cannon Street, with a view to adopting high-pressure inverted gas lamps, with central suspension. The suspension gear will include lowering tackle, so that the lamp can be brought to the side of the street and then lowered, for cleaning and trimming to be carried out at pavement level. The winches for working the gear will be fixed at convenient points on the side walls. It will be interesting to see how the cost of maintenance will work out, and what will be found the best arrangement of the flexible tubing. Readers of this journal will recall that a similar method of suspension has been already experimented with at Stuttgart in Germany, and was recently described in these columns.*

* *Illum. Eng.*, Lond., vol. ii., 1909, p. 639.

Tests of a Gas Lamp in Aldwych.

In a letter to *The Journal of Gas Lighting* for August 9th, Mr. J. F. Simmance gives the following results for one of the Aldwych gas lamps:—

Power of lamp, 50° angle	3712 candles
" " " 20° "	4288 "

He also gives details of the calibration of the standard used which was checked by the Pentane lamp.

He continues: "I would point out that, in future, the correction of the pentane lamp will be necessary for any street lamp tests made under stipulations for actual candle-power. In ordinary gas testing, the relative conditions of the lamp and the test-burner render the correction superfluous; but in direct competition with electricity for street lighting, gas lighting must always be handicapped by its susceptibility to atmospheric conditions."

Notes on Some Early Gas Companies.

We have received from a contributor some interesting documents relating to the founding of two of the early gas companies in this country, The Independent Gas Light and Coke Co., and The International Gas Co., both of which came into existence in the early part of the last century.

The latter company enjoyed the assistance of the celebrated French chemist Clement Desormes. Its aims seem to have consisted in the control and support of local undertakings in a number of different countries. It was, in fact, an early example of the internationalization of illumination, and was described as "calculated to insure the cordial co-operation of Foreign and British Capital, talent, and resources." In passing it is interesting to note that the word "illumination" is used in the prospectus of this company in very much the same sense as it is being used to-day. Thus, in referring to the work of the various local undertakings the prospectus remarks they "have been instrumental in adding to, if not creating, a taste for Gas Illumination." Yet only a few years ago the word rather conveyed the impression of lighting of a festive or decorative character, and it has been put on record that one encyclopædia contains the reference "Illumination—See Fireworks"! It is only quite recently that the term has come into general use to describe the use of light to the best advantage.

The prospectus of the Independent Gas Light and Coke Co., issued in 1824, lays great stress on the desire of the company to fall in with the wants of the public. Attention is drawn to the fact that the several Acts granted to the existing companies took care to provide that the prices should always be lower than that of oil. It is added that "Every suitable attention will be observed towards the Public in the supply of Gas Lights...." and that "Those who consume the gas of the Company will not be subject to any intrusion into their Premises."

The conditions issued for the observance of those taking gas from the company, which are reproduced in facsimile on the **opposite page,** are also interesting. It will be noted that at this time supply through a meter had not become the invariable rule. Instead of this, consumers, if they so desired, could use specified burners and burn their gas at certain stated times; probably, however, in most cases they soon preferred to be charged by the meter, as this enabled them to use any variety of burner and to use the gas any time they desired. It is particularly interesting to observe the company introducing to the notice of consumers a smaller burner "whereby the Consumers will be able to arrange their Lights with more advantage and economy than they can at present do." This certainly bears a close resemblance to illuminating engineering, and is in the spirit of the most progressive modern companies in desiring to help the consumer to make the best use of the gas supplied.

Natural v. Artificial Illumination.

A Denver paper records the fact that during the recent passage of Halley's comet the city lights were turned off for a short period one evening to enable the people to see the wanderer in the sky. So brilliant are the lamps, it is contended, that had not their rivalry been withdrawn it would have been difficult or perhaps impossible to see the comet.

The following is a facsimile of the old document dated March 8th, 1825, and referred to on the opposite page.

THE INDEPENDENT

Gas Light and Coke Company,

OFFICE, NO. 18, TOKENHOUSE YARD, LOTHBURY,

STATION, AT HAGGERSTONE, BY THE REGENTS CANAL.

CONDITIONS

TO BE OBSERVED BY PERSONS TAKING GAS OF THIS COMPANY.

This Company will lay on the Service Pipe and connect to the fittings and make good the Pavement at their own Expence.

In order to insure that the interior Fittings may be perfect, they are to be put up at the Consumers Expence, by persons in the employ, or authorized by the Company, and approved by their Inspector, otherwise Gas cannot be supplied.

To accommodate the Public, the Directors of this Company have come to a resolution of supplying a smaller Burner, whereby the Consumers will be able to arrange their Lights with more advantage and economy than they can at present do, as other Companies will not allow the Consumer the benefit of such a Light.

No Burners allowed but those furnished by the Company. Where the party is supplied with gas through a Meter, any size and description of fancy Burners may be adopted.

The price and times of burning, are set forth in a Scale, which will be delivered to the Consumer agreeing to take Lights.

Persons whose time of burning Gas is uncertain, may be supplied by a Meter, which will be provided and fixed by the Company Free of Expence, in consideration of a reduced quarterly charge being paid by the Consumer, to be regulated by the size of the Meter.

The rent to be collected quarterly, and every in-coming Tenant is requested to give written notice of his intention to continue the Light, at the Office, or at the Station of the Company, that his name may be registered accordingly in the Company's Books.

The prices which will be charged by this Company will be at a reduction of TEN PER CENT. below the charges heretofore made by other Companies. Where the party is supplied by Meter, the price will be at a reduction of FIFTEEN PER CENT.

This Company will guarantee to supply the Gas to any person desiring it for 7 years cn the above Terms.

If any escape of Gas should take place through any defect in the Fittings, the Customer is requested to give immediate notice at the Station, where prompt attention will be paid.

All applications for lighting and causes of complaint, may be addressed to the Secretary at the Office, or sent to the Station of the Company, where every attention will be given, and where a list of duly authorized Fitters may be obtained.

CHARLES WOODWARD,
Secretary.

March 8, 1825.

The Illumination of Fruit and Flowers on Exhibition.

By An Engineering Correspondent.

In view of the large and ever-increasing number of flower-shows in this country, and the more and more elaborate efforts that are now coming to be considered necessary in order to show off fruit and flowers to the best advantage, a few words may perhaps be said on the subject of the illumination to be employed in such circumstances. Several articles in this journal have made detailed reference to the lighting of picture galleries, and the conditions of lighting in such cases resemble in many respects those usually occurring at flower-shows.

In the case of floral displays, just as in the case of picture galleries, the entertainment of those present is mainly achieved through the medium of the eye, and it is therefore only reasonable to urge that the illumination by the aid of which the charms of flowers are revealed is an important factor. Here, again, it is obviously essential that spectators and judges should be free to bestow their entire and critical attention on the blooms, without their eyes being subjected to the inconvenience of ill-placed and dazzling sources of light. It may also be pointed out that correct colour-revelation is absolutely essential in both cases, with the result that reliance is usually placed mainly on daylight illumination, and, further, that a great many objects of interest are usually crowded together in a comparatively small space ; hence some form of diffused illumination is again desirable.

On the other hand it must, of course, be recognized that while buildings devoted to the exhibition of prized pictures are rightly of a permanent character, flower-shows can rarely extend for more than a few days, and the surroundings are usually more or less temporary. There are some buildings which are permanently occupied by horticultural societies, and are devoted to their periodical exhibitions, but local shows are not always able to command the same facilities.

As a rule, the main necessity of a flower-show is the production of a diffused, but yet sufficiently bright order of daylight illumination. In this respect flower-shows, &c., are usually favoured in two ways ; firstly, such shows usually, though, of course, not invariably, take place in the brightest portion of the year, from spring to early autumn ; and secondly, such displays are mainly held in tents and marquees, which are open to the rays of the sun in all directions, and from their semi-transparent nature are often admirably adapted to the production of a uniform soft illumination on any but extremely dull days The writer, when present at a recent show of the National Rose Society in Regent's Park, observed that the canvas tents acted excellently in this respect.

On the other hand, when some local hall is utilized for the purpose, it may be exceedingly difficult to secure even a reasonable approximation to the desired conditions, and the writer can recollect instances in which the light in corners most remote from the windows was anything but adequate. It is often difficult to obtain uniform daylight illumination in large buildings, even for the purpose for which they are intended ; and when such a building is utilized for an exhibition in which minute inspection of detail is required and a good strong light on the flowers is very essential, it is hardly surprising that the conditions should be sometimes unsatisfactory.

Another reason for good illumination, quite apart from the necessity of enabling spectators to see the flowers properly, is supplied by the flowers themselves, which may not open pro-

perly, or at any rate may not be seen at their best, if they only receive an indifferent amount of light.

Moreover, in a competition when a very large number of exhibits of a certain class are on view it is obviously desirable that the displays of all competitors should be treated in exactly the same manner as regards illumination.

In important competitive events and on occasions when new varieties are shown for the first time, it is open to question whether any existing artificial illuminant can be regarded as satisfactory, simply on account of the distortion of colour entailed. For in such cases the merits of a new variety often consist entirely in the production of some novel and delicate shade of colour.

For instance, it will be readily understood that the delicate shades of colour characterizing a novel variety of sweet pea, rose, or carnation might be effectually masked by the use even of the artificial illuminants believed to approach daylight most nearly. For such purposes we still await an illuminant the spectrum of which can be definitely pronounced to resemble that of daylight exactly.

For the purpose of ordinary non-competitive display, however, many existing illuminants offer a sufficiently close approximation to the colour of daylight to answer. In Fig. 1, for instance, is shown an instance of the interior illumination of the orchid houses at the Düsseldorf Horticultural Exhibition, which were lighted by "Regina" arc-lamps.

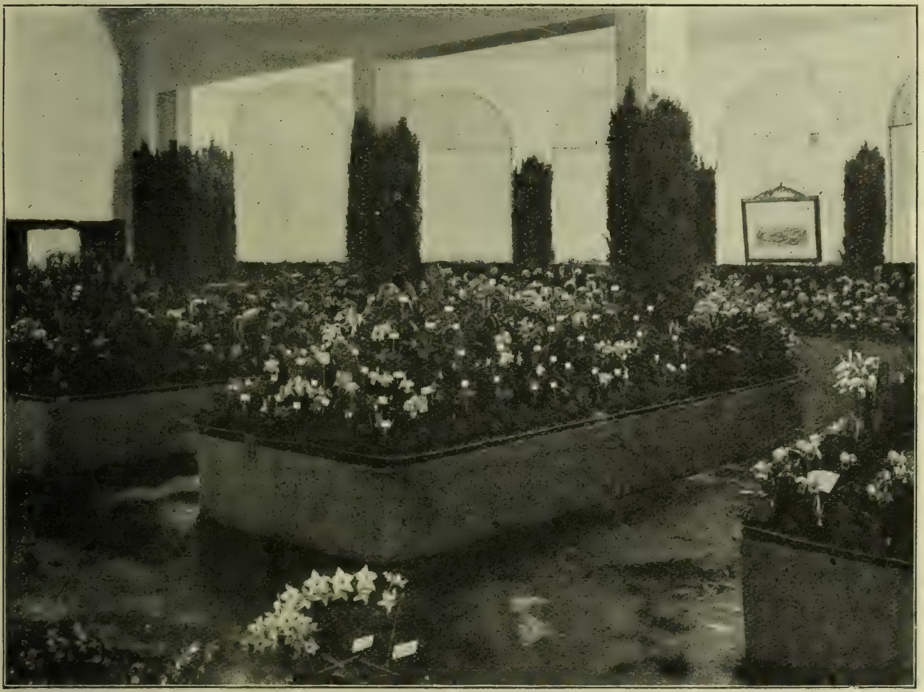


FIG. 1.

FIG. 2.—Artificial Illumination of Orchid-Houses at Düsseldorf Horticultural Exhibition.

In any case, the facilities at the command of modern plant-growers tend to extend exhibitions of floral effects into the winter, when daylight illumination is more difficult to secure. Again many of the public are unable to attend such displays during the daytime. The writer has already pointed out the possibilities of decorative lighting of parks and gardens (*Illuminating Engineer*, August, 1908, p. 680), and there is

at least equally interesting scope for ingenuity in the production of artistic effects in conservatories, greenhouses, ferneries, and water gardens indoors. Here the possibilities of effective local illumination, apart from a general diffused lighting, are very great.

Of course, in all such cases the question must arise how far it is legitimate, from the artistic point of view, to modify and imitate the appearance of nature by the use of artificial light in peculiar ways. The introduction of fantastic dimly lighted lamps may, for instance, lead to interesting effects in the hands of one gifted with the necessary artistic instincts.

The illumination of trickling water and fountains by means of coloured light, again, demands considerable taste and restraint, while the use of miniature fancy lamps, distributed among foliage and designed to imitate fruit or flowers, offers still more debateable ground.

Whatever scruple may be felt in cases in which artistic principles are predominant, however, there can be no doubt of the scope for the application of such spectacular effects in shop windows, &c., for the purpose of attracting attention and showing off fruit and floral goods in an attractive manner, and we already see instances of a striving after effects of this type.

The same holds good for the general exhibits of big horticultural firms at exhibitions.

In florists' shops, where customers are not infrequently obliged to select and judge flowers under artificial light, the question of the colour of illuminant used is again a matter worth consideration. In particular it is essential to bear in mind the conditions under which such flowers are to be used. Flowers intended for use by artificial light on the dinner-table, for example, may, if chosen under daylight conditions, give rise to unexpected and undesirable results.

The question of the possibility of deliberately producing abnormal light effects, for the purpose of stimulating plant-growth in certain desired directions, hardly falls within the scope of the present article, though some extremely interesting results have already been achieved in this way. Yet the risk of light from artificial illuminants causing injury to valuable specimens cannot be said to be of as urgent importance as in the case of picture galleries. Naturally, however, caution should also be exercised in using much artificial illumination, especially new and untried varieties of light, in conservatories. Electric light is here at an undoubted advantage, both as regards flexibility for decorative purposes, and because it does not develope any possibly injurious products of combustion. Whether the deviation of the spectra of artificial illuminants from that of daylight might give rise to injury to valuable and unique plants deserves consideration; but, as artificial light is at present used for such comparatively small periods of time in this way, the question is not very serious.

However, if a time were to come when the priceless collections at Kew were to be thrown open to the public, illuminated by artificial light, during the evening, the effect on the plants of the daily exposure to the rays of such illuminants would have to be borne in mind, and the question of the best quality of artificial light to employ would be an important one. Probably it would be deemed desirable to abstain from the use of sources of light yielding very peculiar spectra.

The Visit of the German Association of Gas and Water Engineers.

The visit of the German Association of Gas and Water Engineers to Great Britain, which was postponed on account of the death of King Edward, has now been arranged to take place during the week commencing October 2nd next. The visitors are to be the guests of the Institutionof Gas Engineers, the Gas Light and Coke Company, the South Metropolitan Gas Company, the Croydon Gas Company, and the Corporations of Edinburgh and Glasgow respectively, of which latter City, the Engineer of the Gas Department, Mr. Alex. Wilson, M.Inst.C.E., is now the President of the Institution of Gas Engineers.

Short Notes on Illuminating Engineering.

From all Sources.

The Effect of Electric Flashes on Eyesight.

SOME time ago attention was drawn in these columns to the suggestion that the sparks of the transmitting apparatus used in wireless telegraphy had an injurious effect on the eyes of operators. A case in which sparks of a different kind seem to have had a similar effect is recorded in *The Daily Telegraph* for August 19th. William Remane, a motorman, brought an action against the Hastings District Electric Tramways Company, Ltd., at the Hastings County Court. He complained of persistent trouble with his eyes arising from the constant electric flashes from the contact system of the tramway. As a result he had suffered from frequent headaches and from an occasional misty sensation of the eyes which had led to a collision. Ultimately he gave up his position as driver on this account, and he now claimed under the Workmens' Compensation Act.

His Honour, Judge Scully, reserved his decision, which will probably be regarded as setting an important precedent. At present a man can claim compensation for an injured limb, and the question may well be raised whether an employer is not equally liable for a steady deterioration in sight caused by the nature of the employment. At present such cases are complicated by the fact that so little is known as to the exact causes responsible for these eye-troubles, and how far they are inevitable. But it may be anticipated that the importance of the industrial question here raised will lead to closer investigations of such effects. This has already occurred in the case of cataract of glass workers.

The Illumination of Machinery and Tools in Factories.

WITH the exception perhaps of picture galleries there is no class of building wherein more use can be made of both general and applied lighting than in factories. The machines installed require each of them one or more lights placed so as to illuminate some particular part. With engineering machine tools, for example, it is necessary for the part where the cutting tool is at work, as well as the device for regulating the depth of cut, to be well lighted ; with the screwing machines in a boot factory the workman must be able to see the screwed-wire feed bobbin as well as the sole of the boot he is screwing. At the same time the other portions of the machine must not be in darkness, nor so lighted that shadows are thrown on any part that may require attention ; during oiling or adjustment, defective lighting might easily be the cause of a more or less serious accident.—*Electricity*, Aug. 12th.

Waste in Street Lighting and the Distribution of Light.

A STREET is a long, narrow thing, and whenever the circle of illumination from a lamp gets much bigger than the breadth of the street, the lamp, however excellent in itself, begins to be wasteful. In other words, if one tries to cover up a yard of tape with bronze, it can be done more cheaply and efficiently with farthings than with pennies.—*Contract Journal.*

Penny-in-the-Slot Public Lighting.

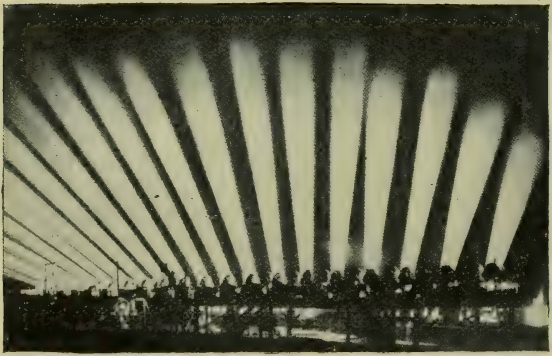
There has recently been considerable discussion, in Paris and elsewhere, on the time of extinguishing street-lamps. Many small towns are faced by the question whether it is desirable, for the benefit of a few belated individuals, to maintain the public lighting throughout the night. An interesting solution of the difficulty has been provided by a little continental community, and is described in the *Berliner Morgenpost* for Aug. 5th.

The road from the boundary of the town of Glogau to the commune of Zarkau, which is rather over half a mile in length, is provided with nine electric incandescent lamps, which amply light this piece of road. The communal authorities pay for the lighting of these lamps until 10 P.M. After this hour, however, anybody can place a 10 pf. piece in either of the two prepayment meters attached to the lamp-posts at each end of the road, when the light will be switched on for twelve minutes—a period sufficient to enable anybody to walk comfortably from one end of the road to the other. The current is switched on in the same way as with the automatic staircase lighting; the prepayment meter being contained in a small and unobtrusive iron box. A shield is attached explaining the object of the meter; and at 10 P.M. it is lighted by a small lamp. The period during which the lamps remain alight is regulated by clockwork.

The Ryan Scintillator.

The device shown here for spectacular illumination, and known as the Ryan Scintillator, is a striking illustration of the American capacity for doing things on a large scale.

It is described as "a glorified electric fountain," in which steam jets take the place of sprays of water, and beams of light from powerful arc lamps are thrown upon them. In the installation which worked with great success in the Hudson-Fulton celebrations in New York last October, 20 arc projectors were used, with a miniature sub-station specially put down to run them. The curtain of steam was varied by using different sets of pipes having a large selection of nozzles, and was augmented by the burning of powder in the neighbourhood.



Very effective colour contrasts are said to have been obtained by rotating the usual colour screens mounted above the projectors, and the auroral effects, similar to those shown in the illustration and produced by arranging the arc beams in a radial pattern, were described as a particularly striking feature.

The Illumination of Skating Rinks.

Among the many special applications of artificial illumination of to-day, the illumination of areas devoted to sport in the evening is one of the most interesting. At one time it was tacitly recognized that sport and athletics could only take place out of doors during the day time. On the other hand, the great majority of people are engaged during the day and would be glad of an opportunity of exercise at night time. The only real obstacle to their doing so is the darkness.

The development of modern powerful sources of light has led to the realization that it is possible to illuminate tennis and racquet courts so that play may take place by night. It is even on record that an important football match took place on an artificially lighted ground. But perhaps the best example of this tendency is the evolution of the roller skating rink, which is almost invariably most crowded after daylight hours. The artificial illumination provided in all these cases has special functions to perform. On a skating rink it is desirable that a good, even illumination should be provided, and that the lights should be so arranged that no inconvenient shadows are cast by the moving figures, and that skaters are not dazzled by bright lights which prevent their seeing where they are going.

The illustration on this page, for which we are indebted to the courtesy of Messrs. Keith & Blackman, Ltd., is an interesting example of the illumination of such a rink by powerful inverted gas lights. It is situated at the Alexandra Palace (N. London).

The Value of Reflected Light from Buildings.

THERE is one factor in street illumination which is often overlooked. In these days, when so much is heard as to the relative merits of different illuminants for street lighting, and when the importance of the access of daylight to offices is receiving increased attention, it is a little surprising that the important rôle played by reflected light from the surface of buildings lining the street is not better appreciated. In certain cities in which the buildings are mainly composed of white stone, and remain clean, the general illumination benefits immensely. In London the exteriors of buildings rapidly approach a grimy condition in which they render little assistance to the artificial lighting of the street, and greatly add to the difficulties of the problem.

But perhaps an even more direct consequence of this griminess is the loss of light in offices facing high buildings. In such cases the amount of sky visible is very small, and it may even be necessary to use artificial light habitually in the daytime. This is simply a consequence of the fact that so little light is reflected from the buildings opposite. On the other hand, when a building has been newly painted, the reflection into rooms opposite it may, on a bright day, be positively dazzling. The writer had recently an opportunity of observing a striking improvement in illumination of an office caused simply and solely by the face of the building opposite being cleaned by the steam cleaner. Now that these methods of scouring the surface of buildings are becoming usual, and the prevention of the smoke nuisance is a less visionary prospect, one might suggest that the benefits of diffused illumination from the outsides of buildings, and the possibilities of assisting street lighting by reflection of this kind, will receive more notice and may play a more important rôle in the street lighting of the future.

The Lady of the Lamp.

THE funeral of Miss Florence Nightingale took place on Saturday, August 20th, and a notable service was held in St. Paul's Cathedral at noon. Many of those who were present were veterans from the Crimea and could recall the enthusiasm which her heroic services then aroused. Among the congregation representatives of practically every nursing association in the kingdom were also present.

An interesting feature among the many floral tributes was a representation of the old-fashioned lantern which Miss Nightingale carried at Scutari and which gave rise to her famous sobriquet of "The Lady of the Lamp." One can well understand how, to wounded men, the distant lamp came to be regarded as an emblem of approaching succour.

Acetylene for Optical Telegraphy.

WE note in a recent number of *Revue des Eclairages*, an account of the use of acetylene in the Austrian army for the purposes of optical telegraphy. An interesting feature of the installation is the use of an oxy-acetylene flame which is projected on to a small block formed of rare earths, and brings this to a high degree of incandescence. This arrangement is superseding the ordinary acetylene flame, as it gives a much more intense light, even approaching that of the arc, and at the same time is more portable than the latter. In some cases, a small acetylene generator is carried with the installation, but more generally both acetylene and oxygen are supplied in cylinders.

An Arrangement for Producing a Variation in the Illumination of a Surface according to a Predeterminated Law.

(Th. Guilloz, Comptes Rendus, Jan. 18, 1909).

THE author describes an ingenious and interesting method of producing a given gradation of illumination on a surface. Many investigators of photometrical subjects have doubtless, at one time or another, felt the need of a convenient method of producing a patch of illumination gradually varying in intensity according to some desired law; for instance, a uniformly altering illumination of this kind would be very serviceable in producing a gradual gradation of light and shade on a photographic plate. The apparatus is essentially as follows :—

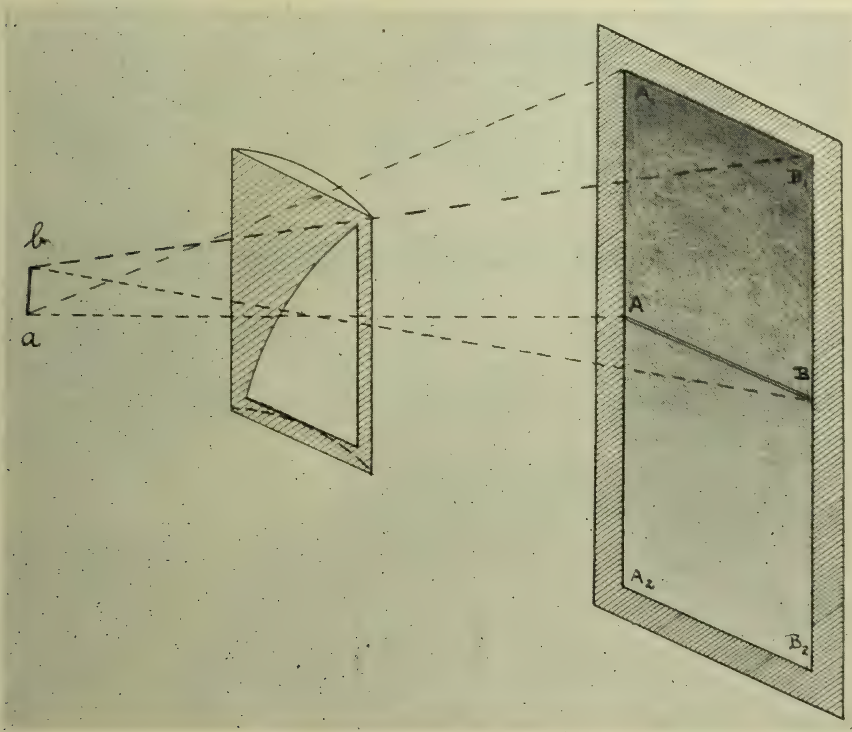


FIG. 1.

A linear source *ab* sends its rays through a cylindrical convex lens, as shown in the diagram, thus producing an image such as A A_2, B B_2. In front of this convex lens is fixed a diagram, the shape of which varies according to the nature of the law, by which the illumination is intended to vary. Suppose, however, for the moment, that no diaphragm is inserted, or, what comes to the same thing, the diaphragm is of a uniform width. Now it can be shown that the rays from *ab* passing through a certain horizontal line in the convex cylindrical lens, will form a corresponding image *AB*. This image receives light only through the agency of the rays passing through this horizontal section of the lens; the same, of course, holds for any other horizontal strip in the image A A_2, B_2 B. If, therefore, the diaphragm is of uniform width, we shall secure a uniformly illuminated image (assuming that the source *ab* is of uniform brightness throughout)

If, however, a diaphragm gradually altering in width is placed in front of the cylindrical lens, the rectangular strip AB will still be uniformly bright horizontally, but this intensity of illumination will be proportional to the width of the corresponding section of the diaphragm through which the rays forming this section of the image pass. As a result we shall secure an integral image A A_2, B B_2 the illumination of which is uniform in intensity horizontally, but gradually changes vertically according to the law represented by the contour of the diaphragm. All that is necessary, therefore, is to shape the diaphragm according to the function $f(x)$ of the prescribed law. For instance, if a uniform rate of change of illumination is desired the aperture of the diaphragm will be triangular, as shown in the diagram.

Holophane, Ltd.

THE above company has been registered with a capital of £200,000 in 100,000 preference 7 per cent shares of £1 each, and 100,000 ordinary shares of £1 each.

Readers of this journal will be familiar with the nature of the scientific glassware manufactured by the Holophane Company, which utilizes specially constructed prisms designed to diffuse or concentrate the light from artificial illuminants in any desired direction. A report of Prof. S. P. Thompson, D.Sc., F.R.S., commenting favourably upon the company's products and processes, has been received, and can be seen at the offices of the company. Prof. Thompson draws attention to the important feature of the Holophane glass in both diffusing the light and avoiding the effect of glare, and at the same time directing the light where it is needed ; he also speaks with approval of the simplicity of the most recent fixtures, notably the "Stiletto" reflectors.

The directors of the company are Mr. O. A. Mygatt (President of the Holophane Glass Co., of New Jersey), Lieut.-Col. F. J. P. Butler, Major G. C. Glyn, D.S.O. (Manager of the Holophane Co., of London), Lord Ernest W. Hamilton, and Mr. R. Woodhouse, jun. The registered office of the company is 12, Carteret Street, Westminster, London, S.W., whence further particulars may be obtained.

Some Publications Received.*

Eck, J., The Application of Arc Lamps to Practical Purposes. (S. Rentell & Co., 36, Maiden Lane, London, W.C., 2*s.* 6*d.* net).

The first portion of this book contains details regarding the efficiency and the distribution and colour of the light yielded by various arc-lamps. Particulars are also given of their application to special purposes as projectors, photo-copying machines, &c. The latter part of the work is occupied by illustrated descriptions of various well-known lamps.

London County Council, Report of the Medical Officer (Education) for 1909.

This contains a section dealing with defective vision and its causes ; also an interesting table comparing the lighting in schools.

City Lighting : The Report of the Engineer for the City of London.

Transactions of the American Illuminating Engineering Society.

This number contains a report of a paper and discussion on 'Selling Electric Light,' an abstract of a paper by L. B. Marks on 'Factory Lighting,' and a contribution by C. R. Clifford dealing with 'Decoration and Illumination.'

Among other publications we have also to acknowledge the receipt of *The Journals of the British, American, and South African Institutions of Electrical Engineers, the Transactions of the Faraday Society, the Journal of the Röntgen Society, the Journal of the Franklin Institute, the Transactions of the American Electrochemical Society, Jahrbuch der Radioaktivität und Elektronik, Zeitschrift für wissenschaftliche Photographie Photophysik, und Photochemie, the Proceedings of the Physical Society of London, the Proceedings of the American Philosophical Society, the Physical Review, the Proceedings of the Tokyo Mathematico-Physical Society, the Journal of the Society of Arts, the Journal of the Society of Architects, the Journal of the Western Society of Engineers, Atti della Associazione Elettrotecnica Italiana, &c.*

* To some of these publications we hope to refer in greater detail shortly.

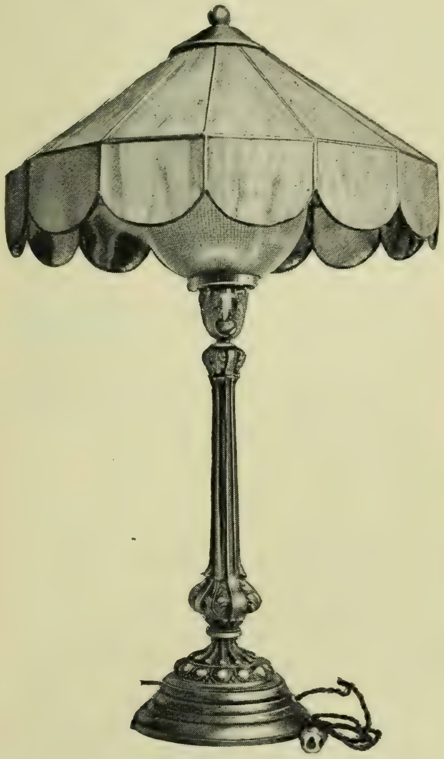
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

THE "G. M." LAMP.

THE small table lamp shown in the accompanying illustration is an interesting example of the combination of decorative appearance with the scientific distribution of light. For reading and writing what is needed is a light which is effectually directed where it is required, and at the same time completely screened from the reader's eye. A coloured shade, illuminated by transparency, may also be an object of decorative value.



The G. M. lamp, which has recently been exhibited at the show-rooms of the **New York Edison Co.** (to whom we are indebted for this illustration), is intended to combine both these principles. It utilizes a Mazda tungsten lamp, surrounded by an appropriate Holophane shade, a leaded glass decorative shade surmounting the whole. In this way the advantages of a uniform illumination without streaks or glare are said to be obtained, the great majority of the light being thrown downwards, where it is wanted; a little of the light, however, is allowed to escape sideways, so as to show up effectively the colours in the leaded glass shade.

"MITCHELLITE" AIR GAS.

WE have received some particulars of the MITCHELLITE air gas system, which by an entirely automatic apparatus is claimed to produce a mixture of petrol vapour and air, afterwards utilized with incandescent mantles for lighting in a manner familiar to readers of this journal. The essential function of a plant of this nature is to maintain the proportions of gas and air constant, irrespective of the load, and to require a minimum of attention at the hands of its owner. These qualities the Mitchellite system is claimed to possess, and, as an illustration of its safety, it is added that this was the only machine allowed by the fire insurance companies and the L.C.C. to make gas inside the building at the Ideal Home Exhibition at Olympia, London, in 1908, and the Building Trades Exhibition in 1909.

It is stated that one gallon of petrol will produce about 1,000 cubic feet of gas, and that 1,000 candle-power hours can be produced at a cost of $1\frac{1}{2}d$. to $1\frac{3}{4}d$.

A USEFUL PATENT EXTENDED SHADE RING.

We have received from the **Sun Electrical Co., Ltd.** (118–120, Charing Cross Road, London, W.C.) particulars of an interesting and convenient innovation, consisting in an extended shade ring, for attachment to incandescent lamp holders. Every one who has been obliged constantly to remove lamp shades attached to electric lamp holders will often have experienced the difficulty of getting one's fingers round the ring and unscrewing it, so as to release the shade. This is very apt to occur in the case of narrow shades, and special tools have been devised to meet the difficulty in shops, &c., where the shades have to be frequently detached for cleaning.

A very simple method of rendering the detaching of such shades a more easy matter, however, consists in the use of the extended ring shown in the illustration. This is naturally much more easy to detach than the ordinary ring, and is threaded so that it can be screwed on to all standard B.C. holders.

SIEMENS "ONEWATTLITE."

A new development introduced some months ago by **Messrs. Siemens Bros., Dynamo Works, Ltd.** (Tyssen Street, Dalston, London, N.E.) when placing their 100 c.p. lamps on the market is now generally known to the trade as the "Onewattlite." It is stated to be specially convenient for shop - lighting installations.

The "Onewattlite" consists of a 100 c.p. "Onewatt" lamp used in conjunction with a suitable design of Holophane Glass Reflector, fitted to a gallery which brings the lamp into true focus and obtains the best possible illumination effects. The price quoted is inclusive of glassware, gallery, and 100 c.p. "Onewatt" lamp complete, with the exception of the lamp holder, and is readily fitted to any existing lamp holder which may be installed. In the case of new installations, however, it would be necessary to order lamp holders extra.

CHEAPER GAS IN PROSPECT.

Consumers of gas in the district of the **Gas Light & Coke Company** will be glad to note that in the speech of the Governor (Mr. Corbet Woodall) at the meeting of shareholders on the 5th inst. it was foreshadowed that there would be a further reduction in the price of gas at the end of this year, making the seventh reduction in eight years.

This continuous decrease in the price charged by the Gas Light Company is very welcome, alike to the consumers, who benefit to the extent of nearly £100,000 a year by every reduction of 1*d.* per 1,000 cubic feet; to the shareholders, whose dividend can only rise as the price falls; and to the employees, whose share of the profits also varies inversely with the price of gas.

WELSBACH ILLUMINATION DATA.

The **Welsbach Co.** (Gloucester City, New Jersey, U.S.A.) furnish us with some additional sheets to be added to the Illumination Data Book, previously received from this firm. It will be recalled that attention was previously drawn in these columns to the excellent booklet issued by the Welsbach Co., containing particulars of their lamps and fixtures. It is their practice to issue new sheets of data relating to each new fixture introduced, which can be added to the books so as to make the series complete.

BRIMSDOWN METALLIC FILAMENT LAMPS.

From the **Imperial Lamp Works, Ltd.,** (Brimsdown, Middlesex) we receive some particulars of the Colloid - tungsten metallic filament lamps made by this firm. The lamps are listed for voltages from 25 to 260, one feature being a 17 watt lamp for 100-135 volts. The lamps are stated to be capable of being burned in any position.

A.E.G. LAMP TRANSFORMERS.

The A.E.G. (Berlin) send us particulars of the small transformers constructed by the firm for reducing alternately supply P.D.'s for metallic lamps. A reduction to 14 volts is considered most satisfactory. It is added that the light load current of such transformers is less than that of the best metallic filament lamps on the market for 110 or 220 volts. A special feature is the use of very small transformers, for use with single lamps, built into the holder.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

A CONSIDERABLE number of British papers refer to the recent report of the City Engineer on street lighting. There is some further reference to the paper on this subject by J. Abady referred to in a previous review. Thus **K. Edgcumbe** (*Electrician*, July 15th) considers that the suggested method of taking the mean of the intensities at angles of 20° and 50° is unsatisfactory. He considers that 15° and 25° would be better, but that it is doubtful whether any adequate conception of the light as a whole could be secured by measurement at any two arbitrary chosen angles.

Several papers in the *Transactions* of the American Illuminating Engineering Society and in *The Illuminating Engineer* of New York also deserve attention. **L. B. Marks** deals with FACTORY LIGHTING. He lays stress on the undesirability of anything giving rise to a "spotty" illumination. For this reason, he remarks, local lighting pure and simple is rarely satisfactory. An interesting point is the use of prismatic glass for windows. In one case this enables a firm to dispense with a series of skylights used to illuminate the room, and thus to save a considerable amount of space. **C. R. Clifford** (*T.I.E.S.*, March) deals with the relation of DECORATION TO ILLUMINATING ENGINEERING. **A. D. Curtis** (*Illuminating Engineer*, N.Y., August) describes an interesting example of the LIGHTING OF LARGE AREAS, namely, the artificial illumination of a big American gymnasium in which baseball is played. The chief point to be observed in this case was the placing of the sources exceedingly high up so as to avoid shadows of moving objects, and the concentration of the light exclusively downwards.

Another remarkable example of the lighting of large outdoor areas was given in *The Electrical World* for July 28th. This consists in the illumination by 80 flame arc-lamps of an arena devoted to a military spectacle in Chicago. Details are given of the distribution of illumination over the ground; this appears to have been of the order of 1 foot-candle.

Among articles of a more photometrical nature reference may be made to that of **E. W. Winkler Buscher** (*Elek. u. Masch.*, Aug. 7), who contributes a lengthy article dealing in a rather exhaustive manner with the GLOBE PHOTOMETER. Besides discussing the theory of the instrument the author gives some data of tests on a Holophane reflector which appeared to absorb about 6 per cent of light. He also points out one important feature of the globe photometer, namely, that it integrates the light in ALL directions, whereas other methods of obtaining the mean spherical candle-power usually assume that the polar curve of illumination is symmetrical about the vertical axis. By the aid of curves for various arc-lamps, &c., he shows that this is rarely the case in practice.

Another article of interest is that by **G. W. Middlekauff** (*Electrical World*, July 21), who describes a form of apparatus for attachment to a photometrical bench and AUTOMATICALLY RECORDING PHOTOMETRICAL READINGS. The author points out that by this means a considerable amount of fatigue is avoided, and the possibility of mistakes in reading the scale is greatly reduced. This point is more important in the case when one experimenter has both to observe his photometer and to read the scale. This is apt to be very fatiguing, and to prejudice the sensitiveness of measurement. By means of the recording device referred to a series of readings appears as a cluster of dots recorded on a special scale of candle-power, and the mean can easily be obtained by subsequent observations of this chart.

Another article dealing with photometers appears in a recent number of the *American Gaslight Journal*. In this a series of new forms of photometrical instruments, most of which were described at recent meetings of the Illuminating Engineering Society in London, are dealt with. An editorial in *The Electrical World* points out the need for a portable standard of light. This is experienced very keenly in connexion with illumination photometers, in which small glow-lamps fed by an accumulator are at present usually employed; the method, however, has several obvious inconveniences.

Several articles deal with the EFFECTS OF ULTRA-VIOLET RAYS. Chief among these is the abstract of a communication from the Institute of Physiology in the University of Paris (*Elek. u. Masch.*, August 7). The authors describe a series of tests of the destructive power of such rays on bacteria. Experiments show that this action is not due to the illumination of H_2 O_2 as was formerly supposed. Experiments were carried out with a Quartz tube lamp producing rays of wave-length as low as $0{\cdot}22\mu$. Rays of even shorter length than this are also produced, but are rapidly absorbed by the air. The authors describe the use of a series of screens enabling the ultra-violet rays to be sub-divided into different varieties, and each quality to be separately studied. It appears that it is chiefly the very short rays, such as are largely absorbed by the atmosphere on their way to the earth from the sun, which are prejudicial to life.

ELECTRIC LIGHTING.

A number of general articles, dealing with the sale of electric light and the effect of metallic filament on central station revenue, have appeared in the United States.

Special mention may also be made of an article by **Dr. B. Monasch** (*E.T.Z.*, August 11th), who discusses INDIRECT ILLUMINATION WITH HIGH CANDLE-POWER TUNGSTEN LAMPS. He compares this method of lighting with various other systems, arriving at the conclusion that, although it is naturally not so efficient as direct lighting by lamps of the same kind, it can compete with inverted arc-lamps. In addition, he thinks that the quality of light is preferable, and that the objection usually urged against inverted lighting, that it is depressing, is less felt with glow-lamps. He adds that inverted lighting both by arc-lamps and tungsten lamps proved more efficient than the Moore light, though giving a similar diffused kind of illumination. His contentions are supported by a series of curves showing the distribution of illumination in each case, the results being expressed in watts per lux per square meter, in accordance with the most recent regulations of the Verband Deutscher Elektrotechniker.

A number of articles deal with arc-lamps. An interesting contribution by **P. Hogner** (*E.T.Z.*, July 21) discusses the EFFECT OF WAVE FORM AND FREQUENCY on the performances of alternating current flame arc-lamps. The watts per Hefner were 0·29 at a frequency of 25 and 0·21 at the frequency of 100. The efficiency is thus increased as the frequency rises. The effect of wave-form is also quite noticeable. A steeply rising curve gives a better result than a gradual one.

F. K. Northrup (*Phy. Review*, July) describes a LABORATORY FORM OF ARC-LAMP intended for photographic purposes and required to operate very steadily. The lower electrode was floated in mercury, and a very steady arc is said to have been secured as a result. By using a steel upper electrode an arc rich in ultra-violet rays was obtained, and it was found very essential that the eyes of the observer should not be exposed to the naked arc.

Among other articles we may refer to the abstract of the recent contribution of **W. Wedding** on the MOORE LIGHT, which appears in *The Electrician* (August 19). An editorial in the same journal deals with the matter, and points out several respects in which the Moore light, in spite of its obvious advantages, is at a drawback. For example, it is stated that at a frequency of 60 the appearance of moving objects is distorted. Again, the fact that the light is not divisible, so that one must either illuminate the whole room or not at all, is also regarded as a disadvantage.

An editorial in *The Electrical World* (August 4) discusses the value of the QUARTZ MERCURY ARC FOR STREET LIGHTING. One incidental advantage commented upon is that the small tubular shape of the source enables it to be readily fitted with reflectors so as to modify the distribution of light in any way desirable.

GAS, OIL, AND ACETYLENE LIGHTING.

There are not many articles to record in connexion with gas lighting.

Several American contributions deal generally with lighting installations and the use of "gas arcs," and an account is given of the lighting of the Sharpsburg Bridge at Pittsburgh (*Prog. Age*, August) by powerful units.

K. Fritzsche describes a new method of AUTOMATIC IGNITION, which does not need any pilot flame (*J.f.G.*, August 6). The method is somewhat unique, involving the use of a pneumatic control and a piece of specially prepared metal, which becomes incandescent when played upon by a stream of gas.

Another German article of interest is the summary of NEW FORMS OF LANTERNS AND STANDARDS in use for street lighting in Strassburg (*J.f.G.*, August 13). There are also several historical articles to be noted, for example, that dealing with "50 years' pro-

gress in gas lighting at Bad Emms" (*J.f.G.*, August 6), the history of the gas company in Munich (*Z.f.B.*, July 30, August 10, 20) and the development of the calcium carbide and acetylene industry (*Z.f.B.*, July 30).

A number of articles in the British gas journals deal with recent developments in High Pressure Gas Lighting. It is stated, for example, that centrally suspended gas lamps are to be utilized in Cannon Street, the arrangements enabling the lamps to be taken to the side of the street and lowered for cleaning and maintenance in the same way as those used in Stuttgart and elsewhere in Germany. An account is also given of the lighting of the railway station at Brighton (*G.W.*, August 20), where inverted high-pressure lamps, taking a pressure of 54 inches of water, are used. An interesting feature in this case is the utilization of the new Keith & Blackman electrical ignition by means of an incandescent platinum wire. Some account is also given of the use of high-pressure gas lamps outside tradesmen's shops in North London, where they appear to have proved very satisfactory for advertisement purposes. Some figures are given for the renewals of mantles; these are said only to amount to between 1.2 and 2.9 per lamp per quarter, according to the locality.

A recent number of the *Zeitschrift für Beleuchtungswesen* contains a reference to a form of burner, the air supplied to which is automatically regulated so as always to secure the most perfect conditions of combustion. This is done by means of a ring which expands as the pressure applied to the burner is increased.

Recent numbers of the same journal contain a continuation of the series of patents dealing with incandescent burners for liquid fuel.

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CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
T. I. E. S.—*Transactions of the Illuminating Engineering Society* (*United States*).
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

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EDITORIAL.

The Second Congres International des Maladies Professionnelles.

On page 599 will be found an account of the Second International Congrès des Maladies Professionnelles, which took place in Brussels from September 10th to 15th. This is the second congress of the kind that has been held, the first being organized in Milan in 1906. In the short period which has elapsed since its initiation, however, this movement for the study of questions connected with industrial hygiene has made very considerable progress.

The Congress was attended by representatives of the Government of different nations, and many of those participating were authorities of world-wide reputation in their respective departments. Its deliberations will doubtless be a valuable record for use in framing future recommendations on industrial hygiene. We cannot make reference to the large number of valuable papers read on this occasion, but refer readers who desire fuller particulars to the complete account of the proceedings which, we understand, will be published in volume form shortly.

It was naturally very gratifying to find that special prominence was given to the subject of illumination, in conjunction with hygiene and eyesight, in the programme of this important Congress, and the Illuminating Engineering Society therefore gladly accepted the invitation to be officially represented on this occasion. This is probably the first time that an essentially medical Congress has received officially the co-operation of those interested in the engineering aspects of illumination, and the important precedent set in this direction at once enlisted the sympathy of the Illuminating Engineering Society. Originally

four delegates, Prof. S. P. Thompson (*President*), Mr. L. Gaster (*Hon. Sec.*), Mr. R. J. Wallis Jones, and Mr. J. Eck were nominated, but Prof. Thompson and Mr. Wallis Jones were unavoidably detained at the last moment. The remaining two members of the Council, Mr. J. Eck and the writer, were present; the latter delivered a paper dealing with the 'Hygienic Aspects of Illumination.'

Quite a number of other papers were submitted dealing with matters connected with illumination, and were most sympathetically received by those present. Dr. A. Broca, Mons. Massarelli, and Dr. F. Terrien, for example, all laid stress on the need for more precise knowledge and recommendations on lighting, and there was a general conviction of the importance of this matter to Insurance Companies and those engaged in the inspection of factories. All parties are really anxious to see better conditions established. The difficulty is that up to the present sufficiently definite data have not been presented for their guidance.

Good Illumination and the Prevention of Accidents.

From the mass of information presented on this occasion two suggestions emerge prominently; that an understanding is needed as to the minimum permissible illumination, and that definite rules are wanted specifying the best means of arranging lights so as to avoid the possibility of their causing discomfort to the eyes. In both cases fairly definite suggestions have already been made. In several countries 10 lux (about 1 foot-candle) has been mentioned as the minimum permissible illumination. Many authorities, again, have independently expressed the view that no source of intrinsic brilliancy exceeding $2\frac{1}{2}$ candle per square inch should be used in a position in which it is constantly exposed close to the eye.

Dr. Broca, in his very exhaustive paper, has also expressed the view that the intensity of illumination ought not, in many cases where fine work is done, to fall below 30 to 40 lux. It may safely be said that any recommendations that may be made in this direction in the future will naturally commence by specifying an absolute minimum, a value, that is, which every one recognizes as the least illumination that can safely be tolerated. But it seems to us quite possible that manufacturers will often prefer to keep well above this figure, because they will recognize that it is to their own advantage to do so. M. Massarelli made one important statement in this connexion. He stated that in his experience employers who adopted improved methods of illumination were mainly influenced by the conviction that the possibility of accidents was largely reduced by doing so.

The need for good lighting arrangements in this connexion seems to us so clear that it must be admitted that the present legislation affecting the safeguarding of dangerous machinery is incomplete. It is not enough, for example, to surround moving machinery with a guard unless its outlines can be clearly seen. There must, therefore, be enough light for this to be the case, and—what is perhaps even more important—the lights must be properly placed. A lamp so placed that its rays fall straight into the eyes of the worker is possibly even more liable to lead to accidents than mere insufficiency of illumination.

We regret that conditions of space do not enable us to refer in greater detail to the many other valuable papers. Mr. A. Glen Park and Prof. Dr. C. Gallenga both pointed out the need for perfect eyesight on the part of those engaged in processes very trying to the eyes; conceivably they might be rendered distinctly less exacting where the conditions of illumination are more perfect. To this and other matters we make reference

in the account of the Congress on page 599.

The importance of a more definite understanding as to methods of recording and expressing results was fully recognized at the Congress, and the international connexion of the Illuminating Engineering Society should be very beneficial in this direction. We therefore trust that this journal will be regarded as a centre of information by all those interested in these matters, and we hope that many of the delegates who participated in the proceedings will give their co-operation by collecting data for presentation at the next Congress to be held in Vienna in 1914.

The Congress of the Royal Sanitary Institute.

Shortly before the opening of the Congress referred to above the annual gathering of the Royal Sanitary Institute took place at Brighton. Here again the subject of illumination received special attention, a paper being delivered by Mr. J. Darch, F.S.I., a member both of the Royal Sanitary Institute and of the Illuminating Engineering Society. Our readers will find a summary of this paper on page 606.

Mr. Darch dealt mainly with the importance of the correct distribution of light, and laid stress on the necessity of avoiding anything in the nature of glare; in this connexion he described several methods of shading lights in such a way that the occupants of a room were not troubled by their direct rays and yet a minimum of light was cut off. Proceeding to practical applications of the principle, Mr. Darch suggested that a more liberal use might be made of good reflecting surfaces both for interior and outdoor lighting, and pointed out the limitations of the present system of street lighting, which often involved the placing of intensely bright dazzling sources against dark backgrounds.

Mr. Darch also referred to the need for the measurement of illumination as a means of specifying precisely what the conditions of good lighting ought to be, and exhibited several forms of instruments for the purpose, including those recently devised by Mr. Haydn T. Harrison and Messrs. Dow and Mackinney, which were described at a recent meeting of the Illuminating Engineering Society.* Mr. J. S. Dow, who was present, subsequently explained the use of this apparatus.

Several other papers read on this occasion, notably those of Dr. Handford and Dr. Parry, dealt with the work of the school medical officer. It was pointed out that the conditions of lighting in many schools left room for great improvement, and that the medical authority was frequently hampered in his recommendations by faulty construction of the building.

Here again, we think, it is to be regarded as an important precedent that a paper dealing specially with lighting matters, and showing their relation to the eye, should have been read before the Royal Sanitary Institute, which has done such magnificent work in promoting an interest in sanitary science. We venture to hope that the Institute will use its great influence to encourage the study of illumination from the hygienic standpoint.

The Transformation of Light.

In this number we describe two recent attempts to make practical use of the phenomena of phosphorescence and fluorescence. The first of these is the type of "phosphorescence illumination photometer" recently devised by W. T. Vivian and G. W. Huey in the United States. In this case an attempt is made to use a phosphorescent material as the standard source, thus doing away with the necessity for a small glowlamp and secondary cell, as usually employed in instruments of this class. As might naturally be expected, the authors find that certain somewhat inconvenient

* *Illum. Eng.*, vol. iii., June, 1910, pp. 373–376.

precautions are necessary in order to secure consistent results. For example, it is stated to be essential that phosphorescent surface should be maintained at a fixed temperature such as that of melting ice, and even so, the brightness of the surface diminishes rapidly after exposure. However, the attempt is interesting, and we shall closely follow further investigations on the subject.

The other development to which we refer is of a different character. It is reported that Dr. Cooper Hewitt has succeeded in utilizing reflectors coated with certain fluorescing materials to supplement the light from the mercury vapour lamp, the contention being that the missing red rays can be contributed in this way, with the result that a light resembling daylight can be obtained.

It will be most interesting to observe how far the inventor's hopes in this direction are fulfilled. It has, of course, long been known that a moderately brilliant light could be secured from these fluorescent substances. The writer has a recollection of some experiments of this kind which he had the privilege of seeing in the United States several years ago in Mr. Hammer's Laboratory. But a difficulty has hitherto been encountered in securing permanence.

Should it, however, be found possible to produce substances which will fluoresce with sufficient vividness to produce effects such as those described by Dr. Cooper Hewitt, and which will preserve these properties for a considerable length of time, a very marked advance in illumination will have been secured. And if, in addition, substances can be made which will maintain their vividness for a long time in the dark, when the stimulating light has been taken away, then great possibilities open out before us.

It is of course too early as yet to say what can or what cannot be done. But it would surely be surprising if the persistent and painstaking work which has been proceeding in different countries in this field during the last few years did not eventually lead to important developments.

The Report on the City Lighting.

The recently issued annual report of the City Engineer contains a considerable amount of useful information on public lighting. We summarize this report on page 613.

That so much space should be allocated to data on street-lamps in a report of this kind is an illustration of the attention now bestowed on illumination. Whatever may be said regarding the effectiveness of street-lighting in London, one cannot but be impressed by the readiness of the authorities to undertake experiments. Whether such investigations are always pursued with a sufficiently definite object, and whether the experiments are not often carried out on a needlessly lavish scale is, of course, another matter. One cannot but wonder, for example, why it should be necessary, before deciding on a system of lighting, to instal lamps over a large portion of a street, sometimes only to be replaced by others after a very short time. London has been described as the laboratory of the world in street-lighting, but the public would probably prefer that the illumination of important thoroughfares at any rate, should not be in a continuous experimental state.

At the same time we fully recognize that properly directed and organized experiments *are* valuable. In this connexion we may again express the hope that a Central and Impartial Authority will shortly be appointed to make the necessary tests, and will issue results which, being backed by the weight of authoritative expert opinion, will constitute a much-needed guide in these matters.

LEON GASTER.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 591) continues his discussion of ERRORS IN PHOTOMETRY. He alludes to the importance of familiarity with the instrument used; an observer will almost invariably get the most accurate results with a photometer to which he is accustomed. Another factor which affects the accuracy of such measurements is the illumination of the screen, and Mr. Trotter presents curves obtained by various observers showing how the sensitiveness of the eye diminishes with decreased illumination. A difference in colour between the standard and the lamp examined is also a difficulty to many observers. There are naturally other causes of error, apart from the observer and the instrument, such as fluctuations in the light of the lamp studied.

Following this (p. 591) will be found a reference to an ILLUMINATION-PHOTOMETER, BASED ON PHOSPHORESCENCE, recently devised by **W. T. Vivian** and **G. W. Huey** in the United States. In this instrument it is proposed to utilize the light from a phosphorescent screen as a standard, but there are several practical difficulties. Not only does the light gradually diminish, but it is necessary to maintain the coating of luminous paint at a constant temperature in order to get consistent results.

On p. 599 is an account of the CONGRÈS INTERNATIONAL DES MALADIES PROFESSIONNELLES which took place at Brussels last month. On this occasion the subject of illumination received important recognition, and, as the Congress is specially devoted to Industrial Hygiene and patronized by the Governments of the respective countries, this is regarded as an important precedent. Several papers were read dealing with the subject of illumination. **Mr. L. Gaster** contributed some remarks on THE HYGIENIC ASPECTS OF ILLUMINATION, in which the legislation of various countries on the subject was summarized, and several illustrations of the effect of good and bad lighting were given. It was also pointed out that bad conditions of lighting diminish the output and prejudiciously affect quality of work, and are apt to lead to accidents and neglect of cleanliness.

Dr. A. Broca also deals with ILLUMINATION AND THE EYE in an exhaustive paper. He discusses in detail the effect on the eye of over-brilliant sources, and emphasizes the relation between illumination and acuteness of vision. In this connexion he advocates a minimum illumination of 30 to 40 lux. **Dr. F. Terrien** and **Mons. F. Massarelli** also delivered papers dealing with the value of GOOD LIGHTING IN FACTORIES, especially from the standpoint of the factory inspector and the insurance company. More definite recommendations are needed. The general conclusion to be drawn from the discussion seems to be that unanimity exists on two points: (1) the necessity of specifying a minimum illumination and (2) the desirability of definite advice as to how brilliant sources can best be arranged so as not to cause discomfort to the eye.

Other papers by **Prof. C. Gallenga, Mr. A. Glen Park,** and others, deal with the conditions of eyesight of workers engaged in various occupations. In the cotton and textile industry, for example, a special examination into the eyesight of applicants for certain departments known to be particularly trying is made; naturally in such cases the provision of good illumination is important in order to reduce the strain to a minimum.

The CONGRESS OF THE ROYAL SANITARY INSTITUTE is referred to on p. 605. The chief item on this occasion was a paper by **Mr. J. Darch, F.S.I.,** who also discussed illumination from the standpoint of its effect on the eye. Mr. Darch, like the other speakers mentioned above, dwells on the value of good shading, and seeks to show how

this can be done with a minimum loss of light. He also points out that much of the interior and exterior lighting of to-day transgresses the laws of good illumination, and suggests that in the future a more liberal use will be made of reflection from light-tinted surfaces. It is also mentioned that, in order to accumulate data regarding conditions of illumination, simple and practical methods of measurement are needed, and a demonstration was given by the lecturer of various forms of apparatus for this purpose.

Several other papers at this Congress dealt with the work of the school medical officer, further evidence being given of the need for improvement in lighting conditions in schoolrooms.

The same subject is discussed in an extract from a recent report issued by **Dr. J. Kerr,** Medical Officer to the L.C.C. (p. 611). In this case stress is laid on the DIRECTION OF LIGHT, which should reach the pupils from the left, and a sketch is given showing how curvature of the spine is apt to be engendered by defects of this kind.

The REPORT ON THE CITY LIGHTING, recently issued by the City Engineer, will be found on p. 613. Full information is given regarding the cost of upkeep of the various lamps used in the City and of the experimental lighting recently undertaken by flame arcs and high-pressure gas lamps.

On p. 615 will be found an account of a paper by **Dr. E. P. Hyde** and **Mr. J. E. Woodwell** dealing with THE MOORE TUBE. An account is given of a number of tests of the distribution of illumination, &c., and reference is made to the stroboscopic effect of the variations in light. An interesting suggestion for the avoidance of this effect is that the tube should be split into two halves and worked with a difference of phase of 90 degrees.

Following this will be found the conclusion of the paper by **Mr. S. E. Doane** in which the series of data dealing with the ANALYSIS OF COSTS OF CENTRAL STATIONS is completed, the final conclusion being that electrical supply companies have a great opportunity in the metallic filament lamps, and that, wisely used, these lamps will eventually lead not to a reduction but to an increase in revenue.

A short illustrated article following discusses several commonly occurring types of OPAL SHADES. It is pointed out that these are often used indiscriminately in shop-window lighting, with the result that the mantles are not adequately screened from the eye. Sometimes the wrong form of shade seems to be used and in other cases it is incorrectly placed. It is therefore suggested that some education in the simple rules of good illumination would be useful to those engaged in the installation of such shades, and a few remarks on the value of instruction to gasfitters in such matters are quoted.

Among other articles in this number reference may be made to the note on the illumination of CHURCH-LIGHTING FIXTURES (p. 632), in which a few remarks are made on the desirability of selecting types of fixtures in harmony with the general architectural scheme of the interior. On p. 597 will be found a discussion of the value of the SMASHING POINT, *i.e.*, the time which must elapse in the life of a lamp before it becomes economical, theoretically, to replace it by a new one. The practical rule, it is suggested, is that a carbon filament lamp should always be thrown away when it is obviously blackened and dull, but a metallic filament lamp ought, as a rule, to be retained until it burns out. Yet another short note (p. 598) deals with the value of Photometry in connection with cases of ANCIENT LIGHTS. In such cases it is often necessary to produce definite evidence that the access of light to an interior has been seriously prejudiced, and actual measurements of the light may be found serviceable in this connection.

Reference should also be made to the series of SHORT NOTES ON ILLUMINATING ENGINEERING (p. 627), in which brief comments are made on a variety of subjects of popular interest.

At the end of the number will be found the usual TRADE NOTES, containing a description of the newly introduced "Silica" quartz tube mercury vapour lamp, and the REVIEW OF THE TECHNICAL PRESS (p. 637).

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Illumination, its Distribution and Measurement.

By A. P. Trotter.

Electrical Adviser to the Board of Trade.

(*Continued from p. 539, Vol. III.*)

Errors (*continued*).

Familiarity with the particular form of photometer.—One who has considerable experience with one or more kinds of photometers may have great difficulty in obtaining good results with an instrument of an unfamiliar type. Long experience with a Bunsen photometer, in which similarity of contrast of two neighbouring patterns is looked for, does not fit a worker for securing good results from an instrument of the equality type, where two contiguous screens may be made to appear identical in tone. Arising from such experience, or perhaps depending upon some psychological principle, the perfect match of the halves of the "equality" Lummer-Brodhun photometer, or of the concentric pattern, does not give such good results, with some workers, as a pattern depending upon slight contrast. The Metropolitan Gas Referees photometer* with its screen of slightly grained paper is preferred by those who are accustomed to it, and in their hands yields excellent results, while those who can do equally accurate work with the apparently structureless material of a perforated screen or simple Lummer-Brodhun find the former instrument insensitive. Some workers prefer a flicker photometer even for comparing lights of the same colour, while others can do nothing approaching to accurate work with it. There is a distinct tendency in some lamp factories to cling to one kind of photometer and to take little interest in improved methods. For lamp testing is done by piece-work, and the testers are reluctant to exchange a photometer with which they can work easily and quickly for another which might, at first, take time and trouble to use.

* *Illum. Eng.*, vol. i. p. 976.

Heavy moving parts, even if moving with little friction, disconcert those who are accustomed to light and freely moving parts. The former must be gradually moved up to the position of balance, the latter allow quick oscillations to be made. Each method is capable of excellent work in experienced hands. Dissatisfaction has been expressed at the innumerable types of photometers, and the desire has been expressed for some standard instrument. The fact is that familiarity with a photometer is of great importance, and if the design and workmanship be fairly good the type matters very little. A corollary is that each man declares that the photometer to which he is accustomed, or which he has invented, is the best.

General experience with photometric work.—It might seem that this is the chief factor in reducing personal error, but it will be found that one who has limited experience with a particular type of photometer can do better work than a highly trained man who tries to use an unfamiliar pattern. Familiarity with a particular photometer seems

therefore to be of greater importance than mere experience in the art. The art is quickly learnt, but it is probable that some persons cannot attain any high degree of accuracy.

Physical conditions of the observer.—It is obvious that a man who is fatigued or out of health cannot work at his best, and this applies peculiarly to photometry, because the operation depends entirely on a subjective impression. A skilful engineer who has to turn a bolt to fit a hole, working with "go" and "not-go" gauges, may be so tired or ill that he may make the diameter too small. He obviously makes a mistake and the result remains. A dyer who has to match a sample of cloth makes a judgment very like that of a worker with a photometer, but there again the result remains, and may be reviewed on another occasion. The difficulty with photometry is that the judgment must be made when the balance appears to be obtained. The operation is fugitive, and cannot be revised unless all the conditions are reproduced. To arrive at an accurate measurement, therefore, the measurement should be repeated several times under the same conditions.

It is well known in experimental psychology that sensation differences diminish after the beginning of a series of tests, fall to a minimum, and then rise. This occurs in photometry. During the first stage the worker makes "sighting shots" to "get his eye in." If he is experienced, this stage may perhaps occupy as little as half a minute, and means that the first two or three observations will often be found untrustworthy, and should be rejected. A less experienced man, or one who is in fact gaining experience, will improve in accuracy during a longer period. The second stage may persist for a long time if the work is not hurried or too continuous. If an observer confines himself to using the photometer, and dictates his readings to an assistant, or if he goes further and deputes the reading of the scale to the assistant, and makes a number of measurements in succession, he will soon become too fatigued to do exact work.

Kennelly and Whiting* suggest that 25 observations under the latter conditions, occupying from 15 to 22 seconds each, is about the largest number that can be made in direct succession without ocular fatigue. These experiments were made with the view of finding the degree of accuracy obtainable with different kinds of photometers under different conditions, and a high degree was, of course, aimed at. Each set was made under the same conditions, and the mean of the 25 observations was taken. Six observers took part in the work, and 850 observations were made.

Besides conditions of ill-health or general fatigue, two kinds of ocular fatigue are liable to cause increased errors. One of these, due to a long succession of observations closely following each other, has been mentioned. This form of fatigue is probably connected with relaxation of the close attention necessary to form a correct judgment, and is of a subjective character, but is also associated with a distinct kind of fatigue due to a persistent image of the photometer screen on the retina. In order to reduce this image, the illumination on the photometer should not be greater than is necessary. Useful as an assistant may be in other ways, it is an advantage to rest the eye between successive observations by reading a properly lighted scale or noting readings in a note-book illuminated to the lowest convenient amount. To look straight at a lamp for examining the height of a flame or the position of a filament, or even to light a pipe, is enough to make accurate work impossible until the eye has recovered, for after spending some time in a darkened room the eye becomes very much more sensitive.

Speed of working.—Except so far as fatigue is concerned, the speed of working has not as much effect on accuracy in photometry as might be expected. With freely moving equipment a measurement can be made to an accuracy of 2 or 3 per cent in 5 or 6 seconds.

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* A. E. Kennelly and S. E. Whiting, *Some Observations on Photometric Precision*, Nat. Electric Light Association, New York. (Chicago Convention, 1908.)

Kennelly and Whiting found that, with lights of similar colour, 22 seconds was the average time taken to obtain an accuracy of 1·5 per cent with a Bunsen photometer, or 0·5 per cent with the contrast pattern of the Lummer-Brodhun. The concentric pattern giving about 1 per cent took about 17 seconds, and the plain equality pattern 0·75 per cent in 15 seconds. The observers were not all accustomed to photometric work. After some experience with a particular kind of photometer, and with arrangements for providing a very free motion of the apparatus, not much improvement in a setting is made after 10 seconds. With heavy apparatus that has to be moved comparatively slowly a longer time is necessary.

In certain lamp factories electric glow-lamps are tested by piece-work. This is generally carried out by girls working in teams of two, one seated in front of the photometer, adjusting it, making the observations, and reading the result either in candle-power at constant pressure or in volts for a given candle-power; the other changes the lamps and marks them.

With a heavy photometer moved up to the point of balance, 1,800 lamps can be tested in a day of 8½ hours with maximum permissible error of half a candle-power in 20, or 2½ per cent. With a Joly or Bunsen photometer easily and quickly movable, as many as 2,500 to 3,000 can be done in a day with a maximum error of ½ in 16, or, say, 3 per cent.

Colour difference. — Kennelly and Whiting found that the superiority of the Lummer-Brodhun instrument almost disappeared when lights of slightly different colours were compared. They did not fall into the mistake so common with other writers on this subject, of using strong colours such as red and green, which may be studied for physiological or purely scientific purposes, with interesting and valuable results, but they confined themselves to such practical colours as those of a carbon glow-lamp at 4·4 watts per candle-power, and an over-run tantalum lamp at 0·93 watts per candle-power. The errors varied from 1·4 per cent with the contrast Lummer-Brodhun to 1·94 with the Bunsen, the former occupying 16·9 seconds and the latter 14·3 seconds. It may seem strange that since there is admittedly a greater difficulty in comparing coloured lights that the average time should be less than when lights of the same colour were compared. An inexperienced person will worry for a long time with the colour difficulty, but after a few attempts he will find that no advantage is to be gained and no further accuracy can be secured by spending time on the comparison. If a 2 per cent error is permissible, the colour difficulty with ordinary ranges between the Hefner and an arc lamp is surmounted with a very little practice. In candle-power photometry a sufficiently brilliant illumination of the screens can generally be obtained to avoid the Purkinje effect. In illumination photometry this difficulty cannot be surmounted, but fortunately in such work it is of no serious importance.

Steadiness of the light.—In some kinds of photometric work the light is perfectly steady, but in others serious unsteadiness must be coped with. Flame standards affected by draughts are sometimes troublesome, but with ordinary care and patience favourable opportunities can be seized for good work. Inferior arc lamps are not amenable to care, and patience must be expended, not in waiting for a steady light, but in taking as many readings as possible from which a mean may be calculated. Such unsteadiness is accidental, but the flicker due to spinning electric glow-lamps for obtaining the mean horizontal candle-power is considered by most lamp makers to be unavoidable. It certainly makes the work more difficult, and therefore less accurate. Surprising results were found by Dr. E. P. Hyde and Mr. F. E. Cady* in studying the effect of flicker due to rotating lamps. With different observers and different photometers the effect of flicker presented marked differences amounting to 7 per cent. See also Kennelly and Whiting, *loc. cit.*

* 'Measurement of Mean Horizontal Candle-power,' *Bulletin of the Bureau of Standards*, Washington, vol. ii., No. 3, p. 426.

The illumination on the photometer.—For candle-power photometry, the amount of illumination on the photometer may generally be controlled, and matters are generally so arranged that it is about ten metre-candles or one foot-candle. When the illumination is less than about 0·1 foot-candle accuracy begins to fall off. Fig. 141 gives results of experiments made by Mr. J. S. Dow and by M. A. Broca on this point.*

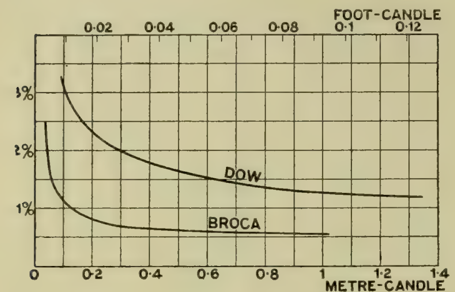


FIG. 141.

Mr. Dow moved a photometer head gradually until a change of illumination could be detected on one side, and then moved it in the other direction until a change could be detected on the other side. The difference between the positions thus found has some relation to the mean error of a single observation, but it largely exceeds that error. In all photometric work a range can be found beyond the limits of which the photometer is appreciably out of balance. The art of exact photometry consists in the attempt to bisect this range.† The personal error of an observer is the error which he makes in this bisection. Mr. Dow's results, and those of several other workers who have investigated the precision of photometers in the same way, must not be treated as the errors of observation.

Broca‡ used a very different method. He employed a Masson disc consisting of a rotating white card with black dots. The dots were really small segments of black rings varying in angular width from 1/44, or 2·27 per cent, to 1/173, or 0·58 per cent of the circumference. Fig. 142 represents such a disc with dots for 0·5, 1·0, 1·5, and 2·0 per cent. He used a gas flame nearly equal to one carcel at distances from 1 to 5 metres.

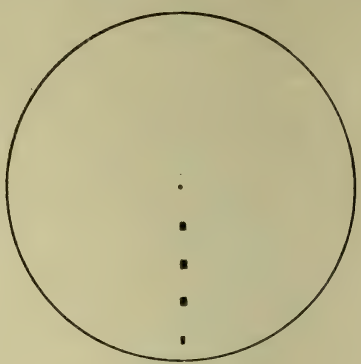


FIG. 142.

The disc being spun, the dots appeared as grey circles. With feeble illumination the fainter rings were not distinguishable. He noted the last ring visible with both eyes and with each eye separately, and found that with both eyes the results were added, or, in other words, greater precision is possible with two eyes than with one.

I repeated these experiments in 1894 or 1895, and cut holes in a white disc, putting black velvet at a short distance behind, thus securing a much deeper black than can be obtained by any paint. There is no record of the results, but I remember being impressed by the importance of using both eyes in a natural manner. A drawback to an experiment of this kind is that one knows the position of the almost invisible ring, and it is difficult not to be misled by imagination. The law of decrease of visibility is well confirmed by Mr. Dow's results, and the fact that in the latter case the precision was less is fully accounted for by the different mode of procedure. A better, but much more tedious way than either of these would be to make five or six sets of ten or fifteen ordinary photometric comparisons, and to take the mean difference from the mean of the

* J. S. Dow, *The Illuminating Engineer*, vol. iii. p. 237. A. Broca, *Journal de Physique*, May, 1894, and *The Electrician*, vol. xxxiii. p. 753.

† Strictly, the geometric mean between the limits should be taken.

‡ *Journal de Physique*, May, 1894, and *The Electrician*, vol. xxxiii. p. 753.

observations of each set, or the probable error of a single observation. Koenig and Brodhun* have made an exhaustive investigation into this matter, but their object was to test the sensitiveness of the retina for acuity, not for an ordinary photometric balance, and they used a diaphragm smaller than the pupil of the eye to eliminate the effect due to the contraction of the iris at the brighter illuminations. With illumination brighter than 1/10 foot-candle precision is lightly improved, but M. Broca puts the maximum at 1/175, or 0·572 per cent, and Mr. Dow at 0·7 per cent. Mr. Dow has also investigated the relation between acuity and illumination. See vol. ii. p. 238. Illumination measurements in ordinary street lighting can be made, as has been stated,† as low as 0·005 with very fair precision.

When the screen of a photometer is very brilliantly illuminated it forms a dazzling patch in a dark room, and precision of measurement is difficult, though the effect is due to the black surroundings, and not to the absolute illumination. The size of the screens, or their apparent size if viewed through an eye-piece, has a marked effect on the error, and where differences of colour exist this becomes a matter of some importance.*

* See Liebenthal, *Praktische Photometrie* p. 155.

† Vol. ii. p. 153.

Instrumental errors.—From the foregoing account of personal errors it is evident that they are largely beyond control; they are constantly varying even when the conditions remain the same, and their magnitude under any given set of conditions can only be determined by investigating the deviation of a considerable number of similar observations from their mean. Instrumental errors, on the other hand, are constant for any given set of conditions. Some of them can be predicted by simple calculation, or they can be controlled or reduced; and for others compensations or corrections can be made.

The most important instrumental errors in photometry have been mentioned in the section on photometers; amongst them are stray light, unsymmetrical construction of the photometer head, departure from the law of inverse squares, introduction of artificial conditions by the use of eyepieces or microscopes, and inaccurate setting of lamps or photometer head with reference to the index on the scale. The setting of the working lamp should be watched; the filaments of some glow-lamps warp and may cause 1 or 2 per cent error.

* J. S. Dow, *Proc. Phys. Soc.*, London, vol. xx., p. 248.

(*To be continued.*)

The Rating of Lamps for Street Lighting.

Just what plan should be adopted for rating street lamps of various types only extended experience can determine. There can be no doubt, however, that a rating based on the initial maximum candle-power in a single direction under the best laboratory conditions is not a fair one to apply to a type of lamp which deteriorates rapidly in service and has a wide range of candle-power in different directions in the vertical plane. The best criterion is the service rendered, and possibly a rating based on the average service obtained will prove the most satisfactory in the end. In any event, it is highly undesirable to refer to a lamp having a mean spherical candle-power in service of, say, 30 c.-p. as a 60 c.-p. lamp, or to designate as 1,200 c.-p. a lamp giving perhaps half that value in spherical candle-power.—*Electrical World*, *N.Y.*, *August 4th*, 1910.

A Portable Phosphorescent Photometer.

(Notes on an article by W. T. Vivian and G. W. Huey in *The Electrical World*).

One great difficulty in the design of portable illumination photometers is the choice of a satisfactory standard of light.

Flames are inconvenient in several respects. They cannot be completely enclosed and boxed up. They require a considerable amount of care in order to secure constant results; being exposed to the air they are liable to be affected by draughts, &c. Their use also prevents the instrument being tilted and used in any position. Partly for the above reasons it is usually accepted that the most convenient form of comparison source to use is a small glow lamp fed from an accumulator. An instrument equipped with a lamp of this kind can of course be tilted in any position, and the fact that the lamp can be packed away in a small space makes for compactness and simplicity in the design. However, even in this case there are difficulties. There is the possibility of variation in candle power owing to the P.D. of the battery gradually falling, while the fact that the battery constantly requires to be charged is also a drawback.

It is natural, therefore, that experimenters have from time to time tried to avoid the use of the ordinary sources of light in illumination photometers by adopting some novel principle. For example the use of selenium has often been attempted, but it does not seem to have yet led to any very practical success in instruments of this kind. A somewhat novel departure, however, is described in an article by W. T. Vivian and G. W. Huey in a recent number of *The Electrical World* (August 18th). The authors made use of the interior of the illumination photometer made by Messrs. Elliott Bros. (London), but instead of the usual glow lamp and accumulator, substituted a phosphorescent surface composed of Balman's paint (the chief constituent of which is stated to be calcium sulphide). The brightness of this surface was compared with that of a standard surface illuminated by the lamps under test.

The authors give values for this brightness of from about 0.00005 to 0.0002 centimetre - candle - units. In making measurements the light from the source tested was gradually reduced by restricting a graduated aperture, it being assumed that the light admitted was proportional to the area exposed.

There were naturally many experimental difficulties to be overcome in using this method. For example, the colour of the light from the phosphorescent surface was so peculiar that it was necessary to introduce a blue glass in the path of the light from the external source, so as to bring the tint of both photometrical surfaces into agreement.

This, however, by no means ended the difficulties of a phosphorescent standard. In order to give the surface the requisite brightness it has to be exposed to a bright light for a certain period previous to use. After this light has been withdrawn the surface continues to phosphoresce, but it appears that its brightness gradually falls for a long time afterwards. For example, the authors present a curve showing that it was reduced by two-thirds in rather over an hour. Indeed, the reduction in brightness is so pronounced immediately after exposure that it is necessary to wait for some time before a condition steady enough to make measurements can be secured. But it is suggested that, provided certain conditions are complied with,

the curve (connecting brightness and time) always follows a very similar course and can be reproduced with fair exactitude.

In using the instrument, therefore, it is necessary to correct values obtained by the aid of a calibration curve connecting the diminution in brightness with the time that has elapsed since exposure.

It is interesting to note that, after a certain point, the brightness is not affected by the time of exposure. This is ascribed to the fact that the film of luminous paint is very thin and is therefore entirely acted upon in a very short time. The brightness does, however, depend considerably upon the intensity of the source to which it is exposed.

Yet another difficulty to which the authors draw attention is the effect of temperature. A rise of 10 degrees sometimes gives as high an increase of brightness as 150 per cent.; they therefore adopted the plan of coating the outside of a metal receptacle and filling its interior with chipped ice and water. It was only after providing a constant temperature in this way that consistent results could be secured.

It will be seen, therefore, that the experimental difficulties in using phosphorescent materials are considerable. But pioneering efforts in this direction are much to be desired, and it is possible that a more complete study of the phenomena of phosphorescence might eventually give rise to results much more hopeful from the practical standpoint. These experiments also illustrate the difficulty that would be encountered in devising a method of artificial illumination based on phosphorescent effects. Yet it has been suggested that persistent investigation might eventually enable this system to be employed for the purpose of illuminating interiors in the future.

The "Smashing Point" of Metallic Filament Lamps and its Value.

By An Engineering Correspondent.

A RECENT communication by F. H. R. Lavender before the Institution of Electrical Engineers contained particulars of a number of tests on metallic filament lamps, many of which appear to have given excellent results. In the course of the paper the author showed how, taking into account the cost of energy and the price of a new lamp, a certain point could be specified at which, *theoretically*, it would pay to throw away a lamp and replace it by a new one. With current at 5*d*. a unit, he suggested, it would apparently pay to throw away lamps after their candle-power had been reduced by only 3 per cent, corresponding to a life of 1,500 hours!

It was pointed out, that, however interesting it might be theoretically, it was often very difficult to apply the "smashing point" system in practice. Even in the case of carbon filament lamps, when the point is fairly definite, an ordinary consumer could not apply the principle, since he has no ready method of ascertaining when the candle-power has fallen by the prescribed amount.

In the case of metallic filament lamps, where the "smashing point" seems to be situated at a point where the candle-power has dropped only slightly, the difficulty is accentuated. For example, it is not easy even for an expert to be confident as to the exact point at which a lamp has fallen 3 per cent, and in any case considerable persuasion would be necessary to induce the ordinary consumer to throw away his lamp when it was apparently as good as new. Practically the conclusion to be drawn was summed up by Dr. Sumpner in the advice to remove a carbon lamp when it is dull, but to use a metallic filament lamp until it gives way.

Another point that might be empha-

sized is that, like many other calculations affecting lighting problems, the smashing point is based on the assumption that our sole object is to get the maximum "light per cost," irrespective of how much light we need. In reality there are always other circumstances to be borne in mind. For example, one can never tell *exactly* how much light is needed for a specific purpose. We can only instal the unit nearest in value to what seems required. In many cases, it may be said that a lamp still does all that is asked of it even when its light has been reduced by 10 per cent. It would therefore be unwise from a practical standpoint to abandon it, even though it has departed from the most perfect theoretically efficient conditions.

Similar conditions limit the application of many of the tables of the relative cost of different illuminants. As a basis of comparison such tables have a real value, once their exact significance is grasped. But naturally no such figures can take into account all the different factors which affect an individual problem, and they cannot be applied indiscriminately. Each case must be decided on its merits.

Ancient Lights and Photometry.

An interesting case in connexion with ancient lights recently came before Mr. Justice Parker in the Chancery Division, and was reported in *The Builder* (July 30). Messrs. Kleinwort, Son & Co. desired an injunction against the City of London Real Property Company, Ltd.

The plaintiffs endeavoured to show that the proposed building really would result in the light in their premises being prejudicially affected, and in support of this contention stress was laid on the fact that although the plaintiffs had already altered their windows under the advice of their architects, the light, even under existing conditions, was not sufficient; it would therefore be very inconvenient for it to be materially reduced by still further obstruction.

On the other hand, an affidavit was presented by Mr. J. Slater, F.R.I.B.A., who considered that the proposed building would not appreciably affect the plaintiff's light, and that the light they would get would be amply sufficient for their business.

Eventually his Lordship granted the injunction, holding that "where there is a substantial diminution in light which, according to the ordinary standard of business men in the locality is already not more than sufficient for business purposes in that locality, such diminution must amount to a nuisance within the meaning of recent decisions."

Seeing that the measurement of illumination has now reached such a feasible stage, it seems surprising that legal authorities should still be content to refer the question whether "there is enough light for business purposes" to local opinion, unsupported by any definite test.

One would suppose that the most obvious and definite evidence of all in a case of this description would be a test of what the illumination in different parts of the premises actually was, or of the daylight coefficient on the lines suggested by Mr. P. J. Waldram and others. Once sufficient information on this subject had been collected and published there would be available a much more substantial basis of judging future cases. In short, it may be suggested that in the illumination - photometer a very valuable weapon is at the disposal of persons interested in ancient light questions, and that the importance of scientific treatment of the subject has not yet been properly appreciated.

The Second Congrès International des Maladies Professionelles.

READERS will recall that in a previous number we summarized the programme of this important Congress* which opened in Brussels, under the patronage of the Belgian Government, on September 10th.

In view of the important precedent established by the recognition of the claims of good illumination at this influential Congress, it was decided that several members of the Illuminating Engineering Society should be present as official delegates. Originally the President, Professor S. P. Thompson, the Hon. Secretary, Mr. L. Gaster, Mr. R. J. Wallis Jones, and Mr. J. Eck, accepted to act in this capacity, but eventually, at the last moment, Professor Thompson and Mr. Wallis Jones wrote regretting their unavoidable absence and expressing wishes for the success of the visit. The other two delegates participated in the Congress, and a paper was read by Mr. Gaster dealing with 'The Hygienic Aspects of Illumination.'

The Congress was exceedingly successful, and has already done valuable work. Over 600 delegates from different nations, many of them representing their respective Governments, were present, and more than 100 papers on various subjects were presented. The object of the Congress, it should be explained, is to deal with a special branch of medical and sanitary science, namely, industrial hygiene. The movement is only about four years old, the first Congress being held in 1906. We understand that the next meeting is to take place in Vienna in 1914. It is worthy of remark that, short as is the period that has elapsed since the initiation of the movement, an institution devoted specially to industrial hygiene has already been erected and equipped under the supervision of Dr. L. Devoto in Milan. There is also a permanent Committee in existence, the President being Senator Dr. M. Cristaforis.

* *Illum. Eng.*, Feb., 1910, p. 88.

We cannot spare space here to make reference to the many exceedingly interesting communications. One subject which received a considerable amount of attention was the interpretation of the term "industrial disease," it being naturally no easy matter, in many cases, to state definitely when an injury is the result of the nature of employment. Several of the delegates also gave full accounts of the nature of the medical supervision in many trades and railways in this country and on the Continent.

What, however, is of chief interest to readers of this journal is the series of papers delivered in Section IV., devoted to the eye and illumination. As explained above, this Congress receives strong Governmental support. Many of the delegates are themselves officials of their respective Governments. Naturally, therefore, the proceedings are of considerable interest to all those concerned with the future legislation likely to be introduced bearing on industrial hygiene. Hence it is to be regarded as a very gratifying and important precedent for the subject of illumination, in conjunction with defects of eyesight, to have been made the subject of a special section.

The following is an abstract of the paper delivered by Mr. Leon Gaster :—

THE HYGIENIC ASPECTS OF ILLUMINATION.

PUBLIC attention has of late years been drawn to the importance of the hygienic conditions under which industries are carried on, and the prevention of industrial maladies. Good ventilation, good air, and adequate sanitation are now regarded as essential conditions for the preservation of health of employees in factories and workshops, and *Good Illumination*, it may be suggested, is every whit as vital.

Moreover, not only the workman, but also the employer, benefits by the main-

tenance of good lighting conditions, for the expense involved in making the necessary improvements is usually trifling in comparison with the better quality and greater output of work which would result. This is now well recognized, and there is a widespread desire for more definite recommendations on the subject of factory lighting.

America and the chief countries of Europe have recently been devoting special attention to the matter. For example, efficient lighting is required in general by the Factory Acts of France, Germany, Switzerland, and the United States. In Holland the employment of women and young children is even forbidden in works in which artificial lighting is normally required between 9 A.M. and 3 P.M. In addition, an illumination of about 1·5 foot-candles is specified as the minimum for certain processes exceptionally trying to the eyes, such as embroidery, engraving, jewellery, draughtsmanship, knitting, quilting, &c., and a minimum of 1 foot-candle in other less exacting occupations. Moreover, it is stated that a special bill relating to the control of industrial lighting generally is also being prepared for introduction into the New York State Legislature.

There is, therefore, good precedent for the view taken by the Home Office in this country as to the importance of this matter. H.M. Chief Inspector of Factories in Great Britain, in his annual report for 1909, laid special stress on the need for good lighting conditions.* In one respect the new sources of light are notably different from the lamps they are superseding. The "intrinsic brilliancy" or "candle-power per square inch" is much greater, and the lights are therefore apt, if misused, to be dazzling to the eye. For this reason it is most essential to arrange the sources wisely, so as to avoid any tendency to glare. Much insistence has been placed on the desirability of establishing a minimum permissible illumination, but the *position* of the sources is at least equally important.

Again, there are many industrial processes, such as those which take place in lamp factories, glass and iron works, welding operations, &c., where workers may be exposed to the rays of these bright illuminants, and proper methods of protection are most important. But it has been suggested that it is not only the intrinsic brilliancy that is harmful. Dr. Stockhausen and others have laid stress on the effect on the eyes of the ultra-violet invisible rays, and attributed the severe inflammation following incautious exposure to powerful lights to this cause; this question requires further examination before definite recommendations can be made.

Yet another aspect of the subject which deserves to be emphasized is the tendency of bad conditions of illumination to lead to accidents. Naturally mishaps are more apt to occur when the machinery cannot be clearly seen, and it is to be noted that the Fidelity and Casualty Co., of New York, in a recent report placed defective lighting first in the list of causes of accident.

It may be added that international co-operation is very desirable in order to secure general agreement as to methods of measuring and expressing illumination.

This furnishes one more illustration of the need for co-operation between engineers, architects, and the medical profession. The engineer ought to bear in mind the views of the oculist, school and factory inspectors, medical officers of health, &c., as to what constitutes hygienic illumination. They in turn could benefit by the methods of precise measurement contrived by the lighting engineer.

The Illuminating Engineering Society was formed in London last year with the object of bringing together these different experts and providing for the collection of the needed data on the subject.

In order to facilitate the exchange of views of experts of different nations on these matters, the Illuminating Engineering Society has also been organized on an international basis, and has among its corresponding members authorities in different parts of the world.

* See *Illum. Eng.*, Lond., vol. iii., August, 1910, p. 493.

ILLUMINATION AND THE EYE.

A very valuable and exhaustive paper was also presented by Dr. A. Broca, dealing mainly with the physiological aspects of illumination and the peculiarities of the eye.

Dr. Broca, whose recent paper on this subject, in conjunction with M. Laporte, will be recalled by our readers,* began by laying stress on the fact that all our impressions regarding surroundings are received through the eye; any complete study of problems in illumination must therefore start with the consideration of this organ.

Brightness.—Dr. Broca had also much to say on the subject of "brightness." He pointed out that in the ordinary course of things the apparent brightness of a surface appears constant as the distance of the eye is increased; this is because the total amount of light entering the eye, and the size of the image, are both reduced together according to the inverse square law. However, we must also bear in mind another factor, namely, the fact that the apparent brightness of a surface depends to some extent upon the portion of the retina on which it is received. A special case is represented by very minute luminous objects, small enough to fall within the area occupied by a single cone. In this case the eye seems to draw its conclusion from the total amounst of light falling on the cone and not from the intrinsic brilliancy of the image; therefore a different law prevails. This may help to explain why the intrinsic brilliancy of a thin incandescent metallic filament tends to appear less than, on theoretical grounds, we should expect it to be.

Glare and the Pupil Apertures of the Eye.—Dr. Broca also gives a list of the intrinsic brilliancies of various common sources, similar to the data given by Dr. K. Stockhausen and others in these columns.

He lays great stress on the inconvenient results of bright lamps in the field of view. The well-known effect of lamps so placed is to cause the pupil aperture to contract, with the result that the luminosity of other moderately bright surfaces is enormously reduced, and they appear very dark and indistinguishable in comparison with the source from which their brightness is derived; indeed, for this reason a bright lamp placed between the observer's eye and the object illuminated may even render it impossible to distinguish the latter at all. The following, for example, represents the contraction of the pupil, and the resulting loss of illumination, caused by placing various sources in the direct range of vision:—

	Pupil Diameter.	Fraction of Light used.
No source in the field of view	12mm (normal)	1
Incandescent Lamp or Flame	8	0·43
Mercury Lamp	6·8	0·32
Arc Lamp in globe	6-7	0·25-0·34
Naked Arc Lamp	5·7	0·225

It will readily be seen, therefore, that the apparent gain in illumination following the use of a naked arc is soon lost, owing to the fact that it causes a marked contraction of the pupil; so that, apart from its inconvenience to eyesight, the use of very bright sources in the direct line of sight is not even economical.

Luminous Efficiency.—Dr. Broca also gave a summary of the chief phenomena in radiation as affects the efficiency of sources of light. In this connexion he gave the following list of figures, which may be added to the already considerable data bearing on the subject:—

Source.	Efficiency. Per cent.
Oil Lamp	2·5
Gas Burner	2·5
Incandescent Burner	5 to 6
Arc Lamp	10 to 16
Acetylene	10
Geissler Tube	33
Mercury Lamp	40

Acuteness of Vision and Illumination.—A series of tests on the effect of illumination on visual acuity have been published by MM. Broca and Laporte (*loc. cit.*). As explained above, the usual effect of a bright light in the field of view is to decrease the effective illumination and so to render it difficult to see detail. Yet, Dr. Broca has found, such a light may occasionally have the opposite effect, especially if the illu-

* *Illum. Eng.*, vol. i., 1908, p. 947.

mination on the detail viewed is very high, so that the loss in brightness caused by pupillary contraction is not of very serious consequence. For this contraction is equivalent to stopping down the lens. It may therefore enable fine detail to appear more distinct to a shortsighted eye, just as a stopped camera lens, while reducing the brightness, makes the image sharper. However, Dr. Broca goes on to point out that though an improvement in visual acuity may conceivably be attained by this means, the effect is apt to be very fatiguing to the eye, and the practice is not to be encouraged.

What should be the minimum permissible Illumination for Reading?—An interesting point is also raised regarding the cause of short sight. It is pointed out that this defect is often the result of poring over books at too close range. But why do children get into this habit? Dr. Broca suggests that the habit is less liable to be contracted when daylight is utilized, because the illumination is then in general so high that the book can easily be read at a distance of several feet. But an illumination of one foot-candle, such as prevails in artificially lighted rooms, while enabling a person to read with comfort at close range, does *not* permit reading at a considerable distance; this naturally leads a reader to bring his book close to the eyes. In support of this suggestion Dr. Broca presents the following figures showing the distances at which a page of print could be read with various orders of illumination:—

Illumination (Lux)	Limiting Distance of Reading (centimetres).	
	Type No. 11.	Type No. 9.
1	80	70
2	105	85
10	145	130
30	160	140
100	180	145

Dr. Broca therefore suggests that it would be preferable to increase the permissible illumination up to 30 to 40 lux (approx. 3 to 4 foot-candles), and so to reduce the tendency to close reading and its attendant evils.

Intensity of Illumination in General Lighting.—In a subsequent part of the paper Dr. Broca deals with the order of illumination that ought to be aimed at in the streets. The actual horizontal illumination outdoors ought not, he suggests, ever to be less than 1 lux. Under these conditions visual acuity is still about 0·6 to 0·7 times that at normal illuminations. Now experience has shown that a man whose visual acuity was as low as 0·1 could, nevertheless, guide himself in the streets (slowly and painfully it is true, but apparently with safety).

Regarding the permissible brightness of objects in the field of view he is of opinion that the oft-quoted figure of Dr. L. Bell, about 0·77 candles per square cm., is still too high, and he prefers a figure not above 0·2 candles per sq. cm. (*i.e.*, rather over 1 c. p. per sq. in.).

Dr. Broca also points out how the standard of illumination has become modified of recent years. At one time the illumination in the Paris Post Office was only 7 lux, which was apparently deemed sufficient. Since 1892 the value has been raised to between 15 and 20 lux. The ideal system for most close work, it is suggested, would be a moderate general illumination supplemented by a local illumination from a well-shaded lamp of about 8 to 10 lux extra.

THE NEED FOR EXACT DATA ON FACTORY LIGHTING.

A very interesting paper was read by M. Francesco Massarelli dealing with the requirements of illumination in factories. This, he points out, is a matter of considerable consequence to insurance companies, especially when they devote special attention to accidents, of which defective conditions of lighting constitute a frequent cause.

M. Massarelli points out that the legislation and recommendations on the subject are too vague to be of real practical service. It is usually enacted, for example, that the illumination must be "sufficient"; but who is to decide exactly what is meant by this provision? And what constitutes "sufficient" lighting? Owing to their vagueness such recommendations come

to be practically dead letters to the technical man. As an illustration of this point M. Massarelli refers to the variations of daylight illumination. Granted that certain conditions with regard to the access of daylight to a workshop have been complied with, it must still be recognized that enormous variations of daylight take place during different parts of the same day and in different seasons of the year. Clearly, therefore, however excellent the facilities for the admission of light, the illumination cannot always come up to the standard of being "sufficient."

As regards artificial lighting the chief conditions to be complied with are steadiness, absence of glare, sufficiency, and good colour. In this connexion M. Massarelli makes a brief survey of the existing methods of lighting available. He refers to the work of Cohn, who specified 10 lux as a permissible minimum. It is particularly interesting to notice his statement that among manufacturers avoidance of accidents is one of the main motives in inducing them to adopt good illumination.

There are, of course, many physiological questions still to be settled. It may be asked, for example, how much light is needed from the hygienic point of view—quite apart from that needed to execute a certain class of work? We cannot do better than summarize the author's concluding words on this matter. "Apart from the well-known injury due to exposure to intensely bright lights, we still know nothing definite as to the effects of the ordinary artificial illuminants on health. It is to be hoped thut scientists and experts on hygiene will one day succeed in furnishing us with definite methods of ascertaining whether any system of illumination is to be considered satisfactory or reverse. Meantime engineers and technical men await their verdict."

RATIONAL METHODS OF LIGHTING AND SUPERVISION OF INDUSTRIAL LIGHTING.

Another paper dealing with factory lighting was presented by Dr. F. Terrien (Paris), who remarked upon the singular fact that amid general questions of hygiene the effects of lighting on eyesight rarely receive sufficient attention. In the legislation on the subject one almost invariably finds that recommendations on illumination are confined to questions connected with the danger of fire from certain varieties of lamps, &c.

The permissible minimum illumination does not seem to have been ascertained with sufficient precision as yet. What, however, is badly needed is some means of readily ascertaining when the eye has become fatigued by exposure to light. One method, due to Katz, consists in observing the number of times the eye winks per minute, the idea being that as the eye becomes fatigued this rate increases. (Another method, suggested by Dr. N. Bishop Harman, was described in our last number, p. 558).

Like M. Massarelli, Dr. Terrien refers to the value of prismatic glass in windows as a means of increasing the illumination. Window shades are often of service, but the colour requires attention; in this connexion it is mentioned that the employees of the Société Industrelle des Telephones once remonstrated against the use of blue blinds on the ground that it affected their eyes.

As regards school lighting the consensus of opinion seems to be in favour of light coming from the left hand of the scholar, though the view has also been taken that a general diffused illumination is also satisfactory. A curious fact, pointed out by this speaker, is that a mixture of daylight and artificial light almost invariably seems to be unsatisfactory, but the reason for this is not quite clear.

As regards artificial illumination, the chief point to be observed is the screening of the eye from direct rays. The suggestion has been put forward that the minimum illumination should be about 10 to 15 lux. This has been specified in the legislation of Holland, and the Conseil d'Hygiene in Paris have been considering a similar recommendation. For fine work, however, as much as 25 lux is needed. Regarding the question of the distribution of light Dr. Terrien like Dr. Broca, takes

the view that an ideal system would be the provision of a good diffused general illumination supplemented by stronger local lighting.

GENERAL CONCLUSIONS.

The papers briefly summarized above were listened to with considerable interest by those present. It was advocated that the Congress should pay increased attention to the subject of illumination with a view to collecting information previous to the next meeting. The occupations of many of the delegates, who are constantly engaged in the examination of the hygienic conditions of factories in their respective countries, would doubtless enable them to render very material assistance to the cause of illumination in this way. The President, in summing up the discussion on this matter, specially emphasized the general agreement between the speakers that it was desirable to specify a minimum permissible illumination for factories and workshops, and the discussion also revealed a strong feeling that the correct placing of lights, so as not to interfere with eyesight, should be emphasized.

OTHER PAPERS OF INTEREST.

Unfortunately space does not allow us to comment in any detail upon the many other interesting papers presented on this occasion. Many of them dealt with matters of direct interest in connexion with factory lighting. Thus Mr. A. Glen Park explained how, in issuing certificates of fitness in the cotton trade, in certain departments special stress was laid upon the necessity for perfect sight on the part of the operator, the work in such sections as knitting, carding, &c., being admittedly very exacting and tiring to the eyes. In such cases the importance of good illumination is evident, since it should serve to minimize the strain and the difficulty of distinguishing fine detail.

Dr. C. Gallenga (Italy) also pointed to the tendency towards shortsightedness among the apprentices in certain trades in which close vision was required.

Another interesting point was the tendency to "nystagmus," a nervous affection of the eyes, on the part of miners. It was suggested by some of the speakers that this was due not only to the peculiar attitudes in which men often had to work, but also to the prevailing deficiencies in illumination and the contrast between the brightness of the daylight outside and the sombreness of the surroundings in the mine.

Yet another item of interest was the account given by Dr. W. Robinson of researches on the cataract of glass-workers. It will be recalled that there has been a suggestion that this defect of vision is caused by the emission of ultra-violet rays from the glowing glass. It appears, however, that while it is very possible that the radiation from the molten material is largely responsible, it has not yet been definitely decided whether it is the ultra-violet or the heat radiation that is to be feared.

It may be added that this country was well represented at the Congress, about 20 per cent of the papers being submitted by British delegates. Dr. T. M. Legge, of the Factory Department of the Home Office, who was largely instrumental in arousing interest in the Congress in this country, delivered papers dealing with lead poisoning and the Workmen's Compensation Act, and a paper of exceptional interest was read by Dr. R. J. Collie on the same subject.

In conclusion, reference should be made to the interesting series of visits and other attractive features on the entertainment programme, and to the able and skilful guidance of the discussions by the distinguished President Dr. A. Moeller. The success of the congress was also in no small measure due to the efforts of the permanent staff and the General Secretary Dr. D. Glibert; and lastly, we must not omit to mention the lucid translations by Dr. René Sand, which were a feature of many of these polyglot discussions.

The Twenty-fifth Congress of the Royal Sanitary Institute.

(Held in Brighton, September 5th to 10th, 1910).

Some Features of Interest in connexion with Illumination.

THE twenty-fifth Congress of the Royal Sanitary Institute was held last month in Brighton, a town whose record as a health resort perhaps rendered it specially appropriate as a meeting place for the Institute.

The congress was formally opened on Monday, September 5th, and a welcome extended by the Mayor, who made graceful reference to the record of the Institute since its foundation in 1876, and laid stress on its services in promoting attention to personal cleanliness, sunshine, and fresh air as a means of combating disease.

THE HEALTH EXHIBITION.

In the Health Exhibition, held in the Dome and Corn Exchange, a series of exhibits, dealing chiefly with sanitary appliances, were set out in an interesting and attractive manner. Illuminating apparatus, however, was not represented as fully as might be desired, the only exhibit of this nature being that of the local electricity supply company. We have no doubt, however, that in time to come more exhibits connected with the use and measurement of light will make their appearance.

Meantime it is gratifying to note that apart from incidental references to the subject of illumination in a number of papers presented at this congress, a precedent was set in the paper by Mr. J. Darch, F.S.I., himself a member both of the Institute and of the Illuminating Engineering Society. With this paper we deal later.

DECORATIVE TYPES OF CHANDELIERS AND FIXTURES.

However, the rooms in which the meetings were held themselves offered points of considerable interest in connection with illumination. Visitors to Brighton will recall that the interior of the Grand Pavilion is decorated in accordance with Chinese design, and many of the vast chandeliers are most striking and original. In Fig. 1, for example, will be seen an immense chandelier in which the ground glass imitation Chinese lilies are utilized, and

FIG. 1.—Central Chandelier in the Banqueting Room, Royal Pavilion, Brighton.

the inevitable dragon is to be seen crawling round the top. Several other similar fixtures will be seen in Fig. 2. The illustrations, however, can give no adequate idea of the striking colouring of many of these objects. In Fig. 3 is shown yet another feature, the illumination of the main corridor with Oriental lanterns. In one respect, at least—the softness of the prevailing illumination and absence of glaring

qualities—this last scheme is worthy of special notice and imitation. The lanterns are of a distinctly original design, and the general effect is quaint and unusual. Here again the illustration hardly does justice to the general effect, as it fails to give an impression of the colours.

All these fixtures are interesting as examples of the use of sources of light, surrounded by appropriate shades and lanterns, for a purely decorative object, quite apart from their function of creating brightness. It will probably be admitted that in order to be effective from the artistic standpoint, objects of this kind must "stand out," but must not be bright enough to cause physical distress; in other words, there must be a minimum of glare.

Joint Visit to Gas and Electricity Works.

One feature of the entertainments deserves passing reference. On Tuesday, September 6th, the members paid a visit to the local Gas and Electricity Supply Works, being received in each case by the engineer. Thus was furnished an example not only of the impartial study of both methods of lighting, but also of the desire of the medical and sanitary profession to know something of the more purely engineering aspects of light-production.

The Inaugural Address.

Mention should next be made of the Inaugural Address of the Hon. Sir John Cockburn, K.C.M.G., M.D., which has been very fully reported in the press.

The address covered a wide range of problems in sanitary science. Attention was drawn to the extraordinary development of public interest in this country in these matters, more remarkable perhaps than at any period since the days of the formulation of the Mosaic law. For this progress the Royal Sanitary Institute was largely responsible, and the valuable Congress on School Hygiene, which had recently taken place in London, was promoted, to a great extent, by their efforts. Some practical examples were mentioned of the need for more precise recommendations on the subject of ventilation. The spectre of consumption, the speaker added, was already shrinking before the combined onslaught of abundant light and fresh air; and the promotion of open spaces and garden cities was an illustration of the importance now attached to these two commodities. Allusion was also made to several respects in which the operations carried out in barber's shops might be rendered more satisfactory from the health standpoint. Sir John Cockburn also commended the work of the Women's Imperial Health Mission,

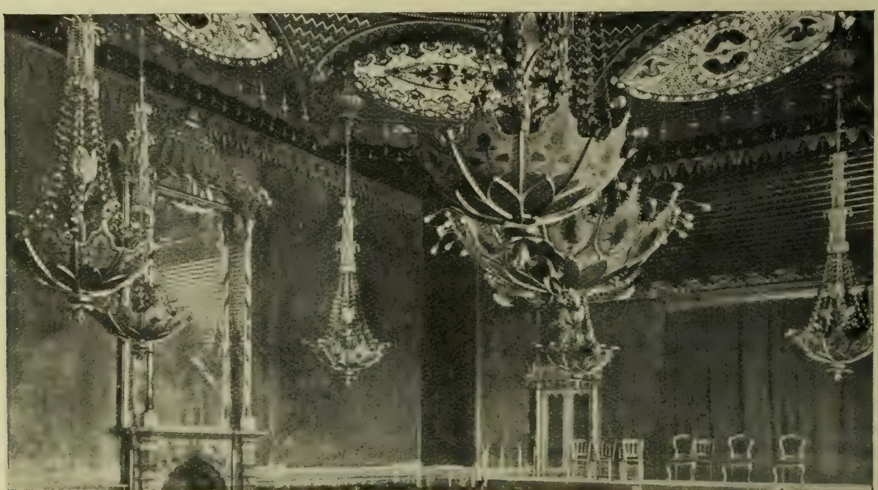


Fig. 2.—Chandeliers in the Music Room, Royal Pavilion, Brighton.

an interesting feature of which carried out the process of education through the eye by the use of cinematographic exhibitions of the right method of carrying out various domestic processes.

The Work of the School Medical Officer.

Conditions of space prevent our making lengthy reference to the large number of papers of interest presented on this occasion. Yet we should like to make some reference to two contributions, both dealing with the work of the School Medical Officer, by Dr. H. Handford, M.D., F.R.C.P., and Dr. A. J. L. A. Parry, M.D., B.S., F.R.C.P., respectively.

Dr. Handford quotes from the code of the Board of Education in which it is clearly stated that "the school medical officer will observe and report instances of bad positions in sitting and unsuitable design of desks and benches. As regards cases of defective eyesight, he will indicate such measures as can be taken to remedy or mitigate the defects by altering the position of the children in the class, or improving the lighting of the school in amount or direction; and he will call attention to the strain imposed on eyesight by the use of too small type in textbooks, the teaching of fine sewing, &c."

There can, therefore, be no doubt of

FIG. 3.—Main Corridor, Royal Pavilion, Brighton, showing Illumination by Oriental Lanterns.

the explicit instructions of the Board of Education as regards lighting.

In the former paper the primary duty of the school officer was stated to be "to prevent the condition of the schools being a source of injury to the health of the children." His work consists, therefore, of two main sections. He must examine the state of health of the children, and he must also examine and analyse the conditions responsible for such defects. Of main interest to us in this connexion is the examination of eyesight and conditions of illumination. It would be interesting to have fuller particulars as to the manner in which this last subject is studied and the steps taken to correlate the results of both lines of investigation.

"Had education authorities in the past availed themselves of the advice of expert medical officers of health," Dr. Handford proceeds, "it would not have been possible to find so many schools with the whole or the majority of the windows still filled with opaque glass, giving a most depressing prison-like appearance to the rooms, and so diminishing the light during a large portion of the year that the eyesight of the children is seriously injured."

Another difficulty in the lighting of schools arises from the fact that an arrangement of the desks enabling the

light to come from the right direction may be somewhat inconvenient for the teacher.

Stress was laid on the same point by Dr. L. A. Parry, who remarked :—

"The natural lighting of many class rooms is bad ; sometimes the light entering is not utilized properly, the the correct arrangement of desks in relation to light being said to interfere with teaching facilities. I consider the eyesight of the children is of vastly greater importance than any slight inconvenience in teaching arrangements." However, an arrangement to give satisfaction in both respects should not be impossible.

In conclusion, reference was made to defects of vision ; 13.5 per cent. of boys and 16.6 of girls proved to have defective sight—*i.e.*, acuteness of vision less than 6/12.

The Eye as it Affects Practical Illumination.

Later in the day a paper was read in abstract by Mr. J. Darch, F.S.I., entitled "The Eye as it Affects Practical Illumination."

Mr. Darch commenced his paper by pointing out that the question of lighting was in many respects a physiological problem—and therefore of direct interest to sanitary engineers and the medical profession. In designing any installation one must bear in mind that the impression of the surroundings is derived through the eye, a physiological organ which has been developed to comply with certain fixed conditions, and the course of evolution of which has been largely determined by its exposure to natural light—daylight.

As a result one found that the eye had been develpped so as to utilise light from above ; therefore brilliant lights placed low down in the field of vision must be considered abnormal and injurious. There are certain qualities in daylight, Mr. Darch added, that must be reproduced in artificial lighting for the eye to be comfortable. The light should be sufficient in intensity, perfectly steady, and effectively diffused, with freedom from violent contrasts ; and it should, as stated, have a downward direction. Yet these conditions were being constantly violated in installations all over the kingdom. He would leave it to medical members to say how far such defects in lighting might give rise to nervous and ocular disorders.

As regards intensity, he thought that for ordinary bench work and reading the illumination should certainly not be less than about $\frac{3}{4}$ to $1\frac{1}{2}$ foot-candles, while for fine work 3 to 10 foot-candles was necessary. The chief factor which served to create an impression of glare was, he thought, intrinsic brilliancy, and he presented a table drawn up tabulating the results of various observers. Dr. Louis Bell had given 5 c.-p. per square inch as the permissible mimimum, but he considered that this was too high for most interiors, and he preferred that 1/10 to 1/20 of a candle per square inch should not be exceeded. The intrinsic brilliancy of a Japanese lantern, as ordinarily used, would not exceed about 0.01 c.-p. per square inch. Another factor to which he alluded was the desirability of avoiding excessive contrast between a bright object and its background, and it had been recommenmended that the ratio between the brightness in each case should not exceed 100 to 1.

In passing Mr. Darch referred to the need for measurement in illumination, and described several forms of simple instruments for determining illumination devised by Mr. Haydn T. Harrison and Messrs. J. S. Dow and V. H. Mackinney. These instruments were shown in actual operation for the benefit of those present, and Mr. Dow, who was present, subsequently explained the nature of his instrument.

Mr. Darch then proceeded to formulate certain simple rules for the illumination of interiors. He pointed out as a truism, which was, nevertheless, ignored in many installations, that the main purpose and object of artificial light was *to render visible the things required to be seen.* One should therefore seek to distribute the light on the objects illuminated where it was wanted, and to avoid allowing it to

stream into the eyes, where it was objectionable. Discussing the merits of direct and indirect illumination, Mr. Darch said that he regarded the former as the most efficient system of the two. However, he preferred a system of shading in which the lights were so screened as to be themselves invisible to the occupants of a room, and yet to allow as much light as possible to pass out into the room in directions in which it could not possibly offend the eyes. The speaker here drew the attention of the audience to a diagram, pointing out how it was possible to fulfil this condition by shading the lights within a certain zone of vision.

Mr. Darch then mentioned several other practical illustrations of his views. He instanced the stages of theatres as an example of sound principles in lighting ; here it was realized that the effect would be spoilt by bright lights between the stage and the audience, and the intention was to illuminate brightly the objects on the stage so that they " stood out " from their surroundings, and assisted the concentration of the attention of the audience. Similar principles ought to be applied to shop-window lighting. Many shop-windows were not, in a proper sense, illuminated ; they were " merely invested with obtrusive lights that advertise themselves rather than the goods." The action of the City authorities in requiring that all shop-lights should be screened on the outside was commendable, but the regulation did not appear to be sufficiently rigorously enforced.

In general Mr. Darch recommended that light should be distributed by being thrown on the objects it is intended to illuminate rather than towards the eyes of the observer. Even so-called " fairy lights " were apt to distract attention and to destroy the legitimate attractions of a room. Staircases, porches, and landings could often be much more serviceably illuminated by a diffused method, the source being screened and the light thrown on a convenient light surface. Even in street lighting the same method might be adopted with great advantage. He believed that in the future much more attention would be paid to the distribution of diffused light in this way, for the intense lights at present in use which, when presented to the eye against a dark background, often serve to confuse and bewilder driver and pedestrian.

In conclusion, Mr. Darch suggested the following simple principles of interior illumination :—

1. The lamps should be so arranged that they are not directly visible from the more frequented parts of the room nor from ordinary points of view.

2. The illumination should be sufficient to enable the objects in the room to be clearly and satisfactorily visible to the eye.

3. In addition to the provision of adequate general diffused illumination flooding the walls, ceilings, &c., there should be a preponderating downward component.

4. Special lighting should be provided for close work at desks and benches, &c., the local lights to be provided with opaque shades and to be adjustable in position.

5. The colour should be, as near as possible, white.

A New Estimate of the Intrinsic Brilliancy of the Sun.

M. C. Nordmann has recently deduced the intrinsic brightness of the sun from some temperature measurements made by his heterochromatic stellar pyrometer.

After allowing for the light absorbed in transmission through the atmosphere, he finds the intrinsic brightness of the sun to be in the neighbourhood of 319,000 c.-p. per sq. cm. It appears that Müller had previously estimated the intensity of illumination of direct sunlight as 60,000 " metre-candles " and the intrinsic brightness, as 301,500 c.-p. per sq. cm.

These two results, arrived at by entirely different methods, show remarkable agreement, their difference being only about + 3 per cent.

A Light-Transforming Reflector.

Many attempts have been made to improve the spectrum of the mercury lamp: among other suggestions, the use of fluorescing substances has been suggested, and Dr. Cooper Hewitt is now reported to have achieved the practical application of fluorescence in order to supply, by the simple means of reflection, the rays normally lacking in mercury spectrum.

As described in a recently issued English patent,* the invention consists in the preparation in a commercial manner of a fluorescent varnish, the light transforming properties of which can be secured in several different ways.

In the preparation of the varnish, three distinct elements are required :—

(1) The fluorescent material, *e.g.*, rhodamine.

(2) A carrier or binder, to bring the material into a state in which it can be practically applied.

(3) A medium to promote fluorescence after the material has been spread out on a surface in the form of a coating.

When collodion is used as the carrier, castor oil is added to the solution to act as a promoting medium, and when these two have been mixed, rhodamine, which has been previously dissolved in alcohol, is added, and a film of the material is prepared in one of several ways. It may be painted on paper or porcelain, &c., as a background, or poured out on to glass and afterwards stripped off.

Another section of the patent describes various methods for causing the reflecting surface to emit efficiently the transformed rays. For example, an ordinary reflecting surface may be coated with the fluorescent material, and placed so as to add the transformed rays to the originally deficient light. This principle is said to have been applied to the mercury vapour lamp with marked success, the resultant light being a very close approximation to daylight, which, it is stated, renders it possible to match colours, &c.—naturally quite out of the question with the original light.

* Patent No. 8449, July 28, 1910.

Another method for securing a satisfactory emission of the supplementary rays, is by incorporating a diffusing medium into the material itself. Zinc white has been found to give good results when mixed with the varnish.

It is important that the reflector should not become over-heated, its efficiency being thereby impaired, and it is suggested that in the case of a gas burner, some refractory material might be used for the part of the reflector which is in close proximity to the flame.

It is suggested, therefore, that the principles of light transformation can, by this new method, be applied to the enrichment of any light having a peculiar spectrum. Thus for the first time a practical method of gaining coloured light by *transformation* instead of by absorbing screens would seem to be secured. Hitherto, when it was desired to obtain light of a special colour, one could usually only attain the desired end by introducing a screen which produced a given colour by suppressing the other parts of the spectrum. But naturally this meant a great waste, and it would be better if we could arrange to convert the wasted rays into light of the useful colour. However, it still remains to be seen how vivid a light can be produced by this means and how long such reflectors will retain their qualities unimpaired. It will be very interesting to discover whether the same method can be employed on a large scale, *e.g.*, for coating the exteriors or interiors of buildings, and so adding to the illumination in the house or the street.

Improvements Needed in School Lighting.

THE recently issued report of Dr. J. Kerr, Medical Officer to the London County Council, again contains gratifying evidence that the question of school illumination is receiving the close attention of medical authorities.

CLASSIFICATION OF LIGHTING OF SCHOOLS.

It is pointed out that in many cases the lighting of school-rooms still offers room for considerable improvement. According to a table containing a summary of the hygienic conditions in 98 schools visited, it appears that out of 288 departments the artificial lighting in 22 cases was only "fair," while in three cases it was considered "bad." The proportion of well-lighted rooms, however, appears to be distinctly higher than that given in some previous tables published by Dr. Kerr, about five years ago*, which seems to suggest that an improvement is taking place. The daylight illumination was apparently less satisfactory than the artificial arrangements, for 60 cases were classed as only fair and 10 as bad.

Unfortunately in many instances there are difficulties in the way of improving the daylight illumination, since the defect usually arises from the construction of the building, the position of windows, &c. Yet much can often be done simply by redecorating the interiors with a lighter tint.

EYESIGHT AND BAD ILLUMINATION.

In some schools a distinct connexion seemed to be traceable between the poor eyesight prevailing and the bad system of illumination. For example, it is stated that at a school in Chicksand Street (Whitechapel), 20 per cent of the children suffered from defective vision, and in about half these cases the defect was very considerable. The report proceeds to point out how desirable it is to have good illumination when a tendency to myopia has been found to exist. In this school the daylight illumination was clearly unsatisfactory. In three of the class-rooms the lighting is from the north-east. The seats are so placed that the children sit with their backs to the windows, and "a heavy band of darkness, especially marked on dull days, falls across the middle of each classroom." In this connection the report remarks "The time has now probably come when a general rule should be laid down that no class-room lighted from behind the scholars should be permitted for schoolwork."

LIGHT MUST COME FROM THE RIGHT DIRECTION.

As an illustration of the evils arising through light coming from the wrong direction the report makes special mention of the tendency towards distorted attitudes in reading and writing. Besides giving rise to unsatisfactory physical development, spinal curvature, &c., these cramped attitudes are very apt to provoke eyesight troubles owing to the child straining its convergence in stooping and bringing the eyes too near the work. Not infrequently, it is suggested, these crouching attitudes are caused by the efforts of the child to place itself so as to secure a better illumination on the book, or in twisting the body so as to avoid its own shadow, &c. On the following page we reproduce from Dr. Kerr's report two illustrations of these contorted attitudes.

We cannot do better than conclude by quoting some remarks from the report bearing on the subject of school-illumination :—

"This most important factor in school premises is still sadly in need of improvement, even adopting the low standard yet accepted, and making

* "Eye-strain and Brain-strain," *Brit. Medical Journal*, 1905.

allowances for the great cost of alterations. Many schools are lighted almost exclusively from the children's back and often high up. Dr. C. W. Hogarth remarks that in some departments maintenance of the straight (correct) position involves writing in a 'blob of darkness,' and Dr. Woodcock notes that infants are often unable to round off their letters. Naturally the children and crouching over the desk, and often with pressure on the chest. Many of the windows may be so dirty that there is a great deal of the direct light absorbed by them. The artificial light is rarely satisfactory for all the children. The back seats are often in comparative darkness. The more powerful recent burners tend to remain concentrated towards the middle of the rooms, and

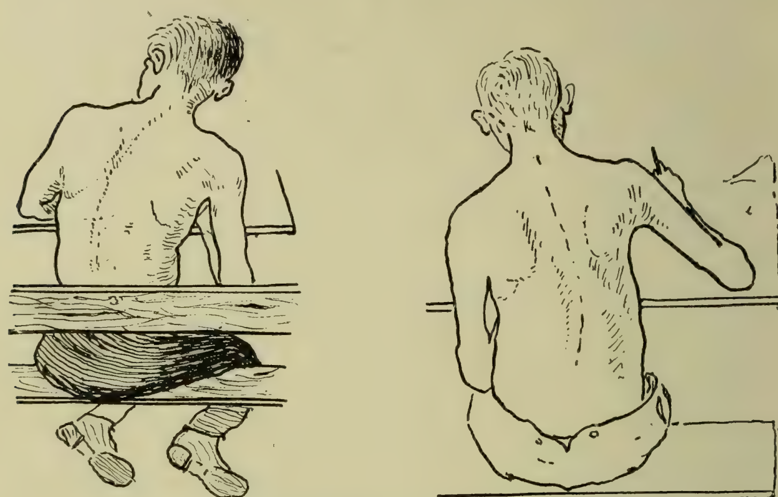


FIG. 1.—Shows cramped and incorrect attitudes assumed by children owing to light coming from the wrong direction.

turn round and sit obliquely to get the best illumination possible for their paper. The alternative to eyestrain is spinal rotation and its attendant evils. It is very common to find a row of desks along the window wall which are always in a condition of half light, what Dr. W. Hawkes terms 'Blind seats,' with resulting constant stooping even then there are all kinds of dark shadows thrown from the arrangement of the lights. During the past year it has been decided that sewing should not be done by artificial light, and this is correct, as it is more tiring than the finest writing, in which there is marked contrast between black ink and white paper."

Photometrical Tests of the Physikalisch-Technische Reichsanstalt for 1909.

A RECENTLY issued report of this Institution contains some particulars of tests on metallic filament and other lamps. In connexion with metallic filament lamps the chief item of progress has been the introduction of 16 H.K. lamps for 100 volts, and consuming 1·0 to 1·1 watts per mean horizontal (Hefner) candle (or 1·4 watts per mean spherical candle).

As regards inverted incandescent gas lamps the best result was about 1·2 litres per H.K. (mean spherical); the best acetylene burner gave 0·2 litres per horizontal Hefner.

The Lighting of the City of London.

(Report of the City Engineer for 1909.)

THE report of Mr. F. Sumner, the City Engineer, for the year 1909, again contains a considerable amount of information on the public lighting of the City.

ELECTRIC LIGHTING.

As regards electric lighting it is mentioned that most of the original arc lamps have been continued during the year, but flame arcs have been substituted in certain thoroughfares, notably Old Bailey, Ludgate Circus, St. Paul's Churchyard, &c. In addition there were 63 Oliver lamps and 18 Reason enclosed arcs in experimental use. These lamps were lighted on 18 days when fog or unusual darkness prevailed at an additional cost of 198*l.* 0*s.* 5*d.* The number of defective lamps reported during the year was 52, and deductions to the value of 12*l.* 9*s.* 2*d.* were made for such failures.

The following table gives the number of arc lamps in lighting on December 31st, with the annual cost of the same :—

TABLE I.

No. of Lamps.	Description.	Price per annum per lamp.	Company.
366	Original type "open" Lamps	£26 0 0	City of London Electric Lighting Co.
53	Oliver flame arcs (partly experimental)	£17 10 0	" "
18	Reason enclosed arcs (experimental), Farringdon Street	£12 10 0	" "
10	Oliver flame arcs (experimental), Cannon Street	£17 10 0	Charing Cross Co.
Total ... 447			

In accordance with the decision of the Court of Common Council in 1907, the Charing Cross and Strand Electric Supply Co. have continued their experiments with 11 centrally hung magazine flame arc lamps in Cannon Street suspended on wires spanning the street 28 ft. above the roadway. The City of London have also continued their experiment with 21 Oliver flame arcs which were substituted for the original ordinary arcs in Holborn, Holborn Viaduct, and part of the Old Bailey. In Farringdon Street 18 enclosed arcs of the Reason type have been maintained during the year.

GAS LIGHTING.

The number of gas lamps (including experimental units) paid for by the Corporation during the year was 2,720, in accordance with Table II.

One interesting development has been the re-lighting of Fleet Street and Chancery Lane experimentally by means of 17 high-pressure inverted lamps of the Keith type. The change necessitated the laying down of a 6-in. high-pressure main in the centre of the roadway, the pressure being 54 ins. of water, the consumption per lamp 25 cubic feet per hour, and the illuminating power 1,500 candles. The inclusive annual upkeep of these lamps, with gas at 2*s.* 5*d.* per 1,000 feet, was 16*l.* 10*s.*, which was subsequently lowered to 16*l.* 0*s.* 10*d.*, and afterwards to 15*l.* 2*s.* 6*d.*, as the cost of gas was reduced. The Gas Company pro-

vided the necessary compressing plant-mains, services, brackets, and lanterns.

There are 102 other high-pressure lamps in the City thoroughfares, including 42 upright single-burner lamps on brackets in Billingsgate. These lamps consume 10 cubic feet per hour, and give an illuminating power of 300 candles each at a cost of 6*l.* 13*s.* 6*d.* per annum. Gas is supplied at a pressure of 10 ins.

TABLE II.

	Ordinary Burners.									High Pressure Burners.						Special.	Total.	
Cub. feet per hour	3	4·25	$\frac{1}{3}$ 4·25	20 4 25	$6\frac{2}{3}$	8·5	12·75	16	21·25	10	20	30	100	25 (in-v't'd)	60		1908	1909
Number..............	10	1978	41	484	1	57	5	2	1	46	45	2	1	17	6	24	2720	2730

There are also 45 upright two-burner lamps in Queen Victoria Street, each consuming 20 cubic feet of gas per hour and giving a light of 600 candles, the cost being 12*l.* per annum.

During the year a trial has been made with the Carpenter South Metropolitan inverted burner lamp in Cheapside and Paternoster Row. The consumption of gas is stated to be 4 cubic feet per burner, yielding a candle-power of 120, or 30 candles per cubic foot of gas.

The number of low-pressure gas lamps at the end of the year was 2,601, the majority being stated to give 60 to 70 candles, and to consume $4\frac{1}{4}$ cubic feet of gas per hour.

The prices paid to the Gas Light and Coke Co. for public lighting by gas was 2*s.* 5*d.* per 1,000 cubic feet during the first half of the year, including a fixed sum of 6*s.* per annum for incandescent mantle renewal for ordinary lamps. From July 1st to Michaelmas the price of gas for lamps north of the Thames was reduced to 2*s.* 4*d.* Subsequently from October 1st to Christmas the Gas Light and Coke Co. reduced the candle-power of their gas from 16 to 14, and the price of gas was then lowered to 2*s.* 2*d.* for lamps north of the Thames.

The number of defective gaslights observed and reported upon during the year was 1,841, including 1,495 ordinary and 346 high-pressure lamps. The details of the total defects observed in the ordinary lamps during the year were as follows :—

Defective Lights.		Defective Lanterns.							Total.
Feeble Lights.	Lights Failed.	Bottoms.	Tents.	Sides.	Doors.	Dirty.	Protectors.	Burners.	
1,276	20	25	9	30	2	66	55	12	1,495

The remainder of the section of the report dealing with lighting is devoted to data collected by the Deputation of the Streets Committee which visited various cities on the Continent* and contains a table summarizing the conditions of lighting in the various towns visited on that occasion.

* See *Illum. Eng.*, vol. ii., 1909, pp. 526, 623, 677.

Tests of Moore Tube Lighting Installation New York Post Office.

By E. P. Hyde and J. E. Woodwell.

(A paper presented at the Third Annual Convention of the Illuminating Engineering Society, New York, Sept. 27, 28, 29, 1909; abbreviated.)

Description.

The tests reported below were conducted in June, 1908, by the Bureau of Standards, at the request of the Treasury Department, on two Moore tube hairpin units located in the "City" room of the Registry division of the New York Post Office, after the tubes had been in constant service approximately 5,000 hours. The tubes were operated on the 220 volt, 60 cycle central station service, and were fed with nitrogen gas.

The general arrangement and dimensions of the room and its furniture are shown in plan, Fig. 1, which also shows the lengths and position of the Moore tubes, size and form of reflectors with which the tubes were equipped, and the test stations at which illumination measurements were made.

The ceiling of the room had just been painted a light buff colour.

The room marked D on plan, Fig. 1, adjoining the side opposite the Light Court, was separated by a wire screen only, and was also illuminated by Moore tubes.

Scope of Tests.

The tests were divided into five general heads, as follows :—

1. Illumination measurements at various stations to determine quantity and uniformity.
2. Measurement of energy and power factor.
3. Determination of flux of light.
4. Stroboscopic determination of variation in illumination throughout a cycle.
5. Study of colour.

1. Illumination.

The illumination was measured by means of a Sharp-Millar illuminometer, previously calibrated at the Bureau of Standards. This calibration showed the scale of the instrument to be in error over a range from 18 foot-candles to 1·5 foot-candles by approximately 9·5 per cent. By a preliminary test the voltage of the small comparison lamp, furnished with the instrument, at which it matched the Moore tubes in colour, was determined. The instrument was then calibrated with the comparison lamp at this voltage, both as an illuminometer and as a photometer. The milk glass screen was tested when light was incident at various angles, and found to vary from the cosine law by as much as 20 per cent. at 75° incidence. A curve was made showing this error for different angles of incidence. Curves were also obtained giving the actual foot-candles for any scale reading when the instrument is used as an illuminometer, and the actual candle-power when the instrument is used as a photometer.

The illumination was determined on a plane 36 in. from the floor, at the various stations indicated in Fig. 1.

For the first series of readings the reflectors over the tubes were removed. For the second series they were in place. The reflectors used were corrugated mirror reflectors, and are shown in Fig. 1.

The last 8 ft. (end away from transformers) of double tubes A and B were added after the reflectors were made and consequently remained without reflectors as in the first series. During

the readings at the first five stations in Series 1, the tubes in room D were lighted. They were then put out; a second reading made at station 5 showed no appreciable change. After this the tubes in room D remained out until station No. 14 was reached, and were then turned on. Tube C was in during the first series up to station No. 14 when it was put out for the rest of the series. In series 2, the tubes in room D as well as tube C were out. At station No. 14, series 1, readings were taken with the observation plane at different elevations from the floor in order to determine the effect on the illumination in change of distance from the tubes.

The results given in the following table are expressed in terms of the unit of candle-power maintained at the Bureau of Standards prior to July 1st of the present year.

The floor area illuminated by tubes A and B approximates 1,675 sq. ft., so that the watts per sq. ft. are 2·85.

3. Flux.

For the purpose of determining the flux, a space was screened off enclosing about 15 ft. of tube B. This screening was accomplished by erecting four uprights at the corner of a 15 ft. square and wrapping around them heavy felt cloth forming a room from which practically all extraneous light was excluded. A brass piece with an opening exactly 1 ft. long was made to fit the tube, and when set in place, the remainder of the tube within the enclosure was wrapped with felt, so that the only light within the enclosure came from the 1 ft. length of the tube. A semi-circular disc was made with a piece exactly fitting this 1 ft. opening. This disc was provided with an adjust-

Table I.—Illumination in Foot-Candles.

Stations.	Series No. 1 without reflectors.		Series No. 2 with reflectors.	No. 2 less No. 1 in per cent.
1	2·4		2·5	4
2	6·2		6·9	10
3	7·8		8·3	6
4	7·9		8·6	8
5	5·0		5·2	4
5	5·0	Tubes in room D out		
6	2·5		2·6	4
7	5·9		6·2	5
8	8·6		9·1	5
9	9·0		10·0	10
10	7·3		7·4	1
11	3·7		3·7	0
12	3·4		3·4	0
13	7·8		8·7	10
14	8·8	36″ Reference plane from floor	10·0	12
14	9·6	48″ ,, ,, ,, ,,	10·4	8
14	10·3	60″ ,, ,, ,, ,,	10·5	2

Note.—Neither tube C nor tubes in room D should affect measurements except at station 12, where tube C would have some effect.

2. Energy.

During the illumination measurements energy readings were made on tube B, in series 1, and tube A in series 2. The connections are shown diagrammatically in the sketch, Fig. 2.

The results are given in Table 2.

able rod swinging about the centre of the edge of the disc nearest the tube. The other end of the rod was provided with a small flat disc whose plane was perpendicular to the axis of the rod. By the use of this apparatus it was possible to set the illuminometer tube at a definite distance from the Moore tube, and with its axis making a definite angle with the axis of the Moore tube.

The rod A was made in several lengths, approximately 4 ft. long, and

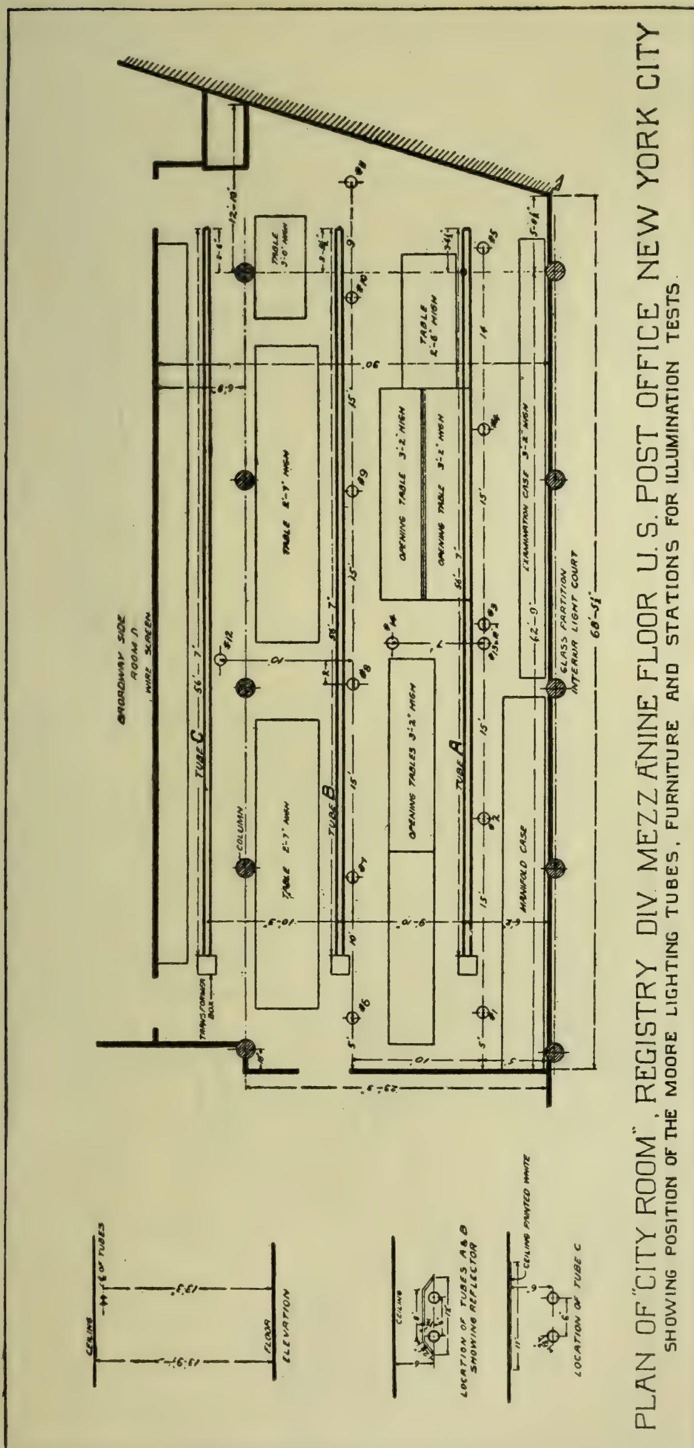

PLAN OF "CITY ROOM", REGISTRY DIV. MEZZANINE FLOOR U.S. POST OFFICE NEW YORK CITY
SHOWING POSITION OF THE MOORE LIGHTING TUBES, FURNITURE AND STATIONS FOR ILLUMINATION TESTS
BROADWAY SIDE
ROOM 11
WIRE SCREEN
TUBE C
TUBE B
TUBE A
COLUMN
TRANSFORMER BOX
TABLE 2'-7" HIGH
TABLE 3'-0" HIGH
TABLE 2'-6" HIGH
OPENING TABLE 3'-2" HIGH
OPENING TABLES 3'-2" HIGH
ILLUMINATION CASE 3'-2" HIGH
MANIFOLD CASE
GLASS PARTITION
INTERIOR LIGHT COURT
68'-5½"
ELEVATION
CEILING
FLOOR
LOCATION OF TUBES A & B SHOWING REFLECTOR
LOCATION OF TUBE C
CEILING PAINTED WHITE

Fig. 1.

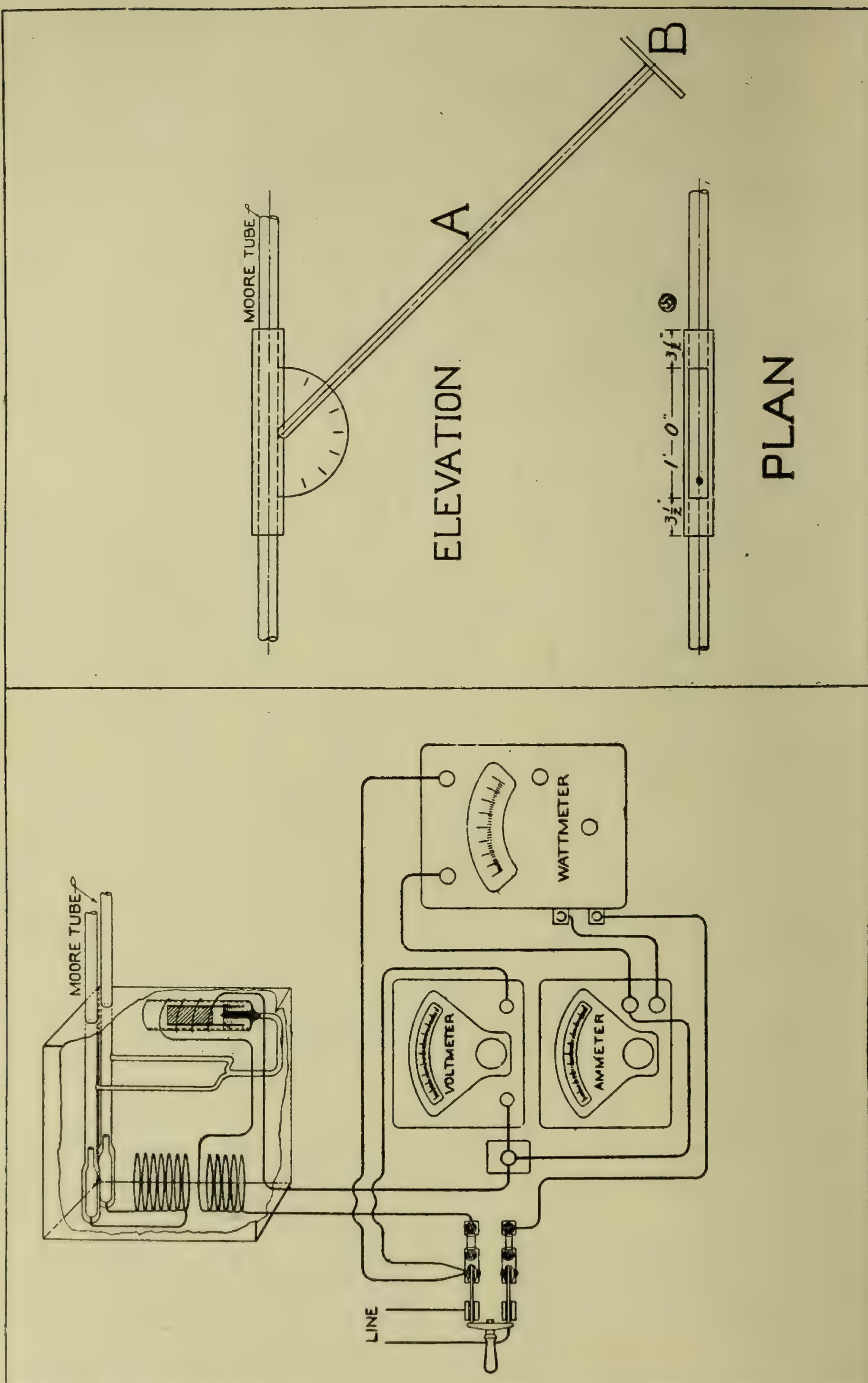


FIG. 2.—Showing connexions for determination of energy and powerfactor of tube and also for study of flux.

the disc B could be attached at the end of any length. The illuminometer was changed during the test so as to serve as a photometer, by removing the milk glass screen and replacing the mirror at the elbow by the diffusing screen. The first measurement was made with the photometer directly under the opening, so that the photometric axis made an angle of 90° with the axis of the tube. This was called the 0 angle. The distance used was approximately 4 ft. The photometer was then moved, raised and adjusted by means of the rod and disc until its axis made an angle of 20° with that of the tube.

Table II.—Average Energy Consumed during Series 1 and Series 2.

	Volts.	Amperes.	Apparent kilowatts.	Actual kilowatts.	Power factor per cent.
Series 1—Tube B	210	18·8	3·95	2·50	63
Series 2—Tube A	213	15·4	3·28	2·27	69

Readings were taken at the angles 0°, 20°, 40°, 60°. At 60° the readings were repeated as a check, and at 0° an additional observation was made at a longer distance. The results are expressed in apparent candle-power which in this case means the candle-power which a point source placed at the centre of the tube must have in order to produce, at the given distance, the illumination measured.

Table III.—Flux Test.

Angle, degrees.	Distance in feet.	Apparent candle-power
0	4·43	9·4
20	4·48	9·4
40	4·45	9·1
60	4·50	8·3
60	4·50	8·3
0	4·43	9·4
0	10·48	9·2

It is evident that when the photometric axis is normal to that of the tube, light will fall on the photometer screen at different angles of incidence, depending upon the distance of the screen from the tube and the distance of the different light-giving portions of the tube from the intersections of the photometric axis and the tube axis. It was found by analysis that the decreased illumination produced by these effects was compensated for by the fact that the light received on the screen does not come from the cylinder 1 ft. in length, but from a cylinder of wedge shape whose front elements are 1 ft. in length, but whose rear elements are considerably longer. It was found, therefore, that to a very good degree of approximation, probably well within the errors of reading, the mean spherical candle-power could be computed from the results obtained, assuming the candle-power to be that of a point source located at the centre of the tube. This mean spherical candle-power was found to be 9·0. From this we get the total flux from 1 ft. length of the tube to be 113·1 lumens. Since the total length of the tube B is 2 $\times$ 56′ 7″ (see Fig. 1) or 113·17 ft., we have as the total flux from tube B, 113·17 $\times$ 113·1 = 13,000 lumens. Assuming the power to be 2,500 watts (see Table 2), we have as the efficiency 5·21 lumens per watt. The mean spherical candle-power of the tube as a whole may be taken as the lumens divided by 4π or 1,034.

The watts per mean spherical candle for tube B will then be 2·42. Assuming the same value for tube A, the spherical candle-power per square foot of the area illuminated by tubes A and B, will be 1.18.

4. Stroboscopic Test.

Owing to the fact that when a tube is running on single phase there is a succession of images of any moving object instead of a continuous image, a stroboscopic test was made to deter-

mine the fluctuation in illumination and to see if a remedy could be found by using two phases, 90° apart.

The stroboscope used was made by attaching to a small induction motor a disc having a small sector opening in it. The motor was mounted on an arm which turned about a vertical axis passing through the axle of the motor. The speed was adjusted so as to to give four maxima and four minima per turn. In this way it was not, necessary to turn the instrument through more than 180° in order to pass from a maximum through a minimum. This procedure was necessary because the tube of the illuminometer prevented a complete rotation of the arm holding the motor.

The stroboscope was first set up half-way between the tubes A and B, and at a height approximately six feet from the floor. When both tubes were running on the same single-phase current, the range between the maximum and minimum was from 0·096 foot-candle to less than 0·012 foot-candle, or at a ratio of 8 to 1. Owing to the finite size of the opening in the stroboscope disc, and the finite size of the screen of the illuminometer, it is impossible to get a zero illumination when the current is at the zero point of the wave cycle.

The two tubes were then put on separate phase, 90° apart. In this case one of the circuits was a power circuit involving the possibility of fluctuations in the line voltage. The range was then from 0·16 to 0·08 foot-candle, or a ratio of 2 to 1, as compared with a ratio of 8 to 1 on single phase.

It is evident from the results of this test that the objectionable flicker noticed in moving objects, when both are on the same phase, can be largely cut down by running the tube on two phases 90° apart.

Some Further Tests on the Moore Light.

An investigation of the Moore light carried out a short time ago by Prof. Wedding, and recently described in *Elektrotechnische Zeitschrift*, brings out some interesting points in connexion with this form of lamp. Prof. Wedding found that the effect of change of frequency was very marked; *e.g.*, with primary voltage constant at 153 volts, an increase of frequency from 36 to 60 so diminished the secondary voltage that the candle-power fell very considerably. At this low voltage the flickering was excessive.

Efficiency tests showed that the over-all efficiency of the particular set used was 1·53 watts per candle (Hefner), but neglecting the loss on the transformer and the choking coil, the latter being used in the same way as a series resistance in an arc lamp, the efficiency of the lamp itself worked out at 1·34 watts per candle.

An interesting comparison was made by lighting a given room with the Moore light and also with Tantalum lamps, the energy consumed in each case being the same. When the illumination of the room had been mapped out under each system, at a given height from the ground, it was found that with Tantalum lamps the illumination varied from 29·4 to 48 Hefner candles, the mean being 37·3, whilst with the Moore light the variation was from 32·4 to 46 Hefner candles, the mean being 39·4.

It is also stated that the tube of gas possesses a marked inertia, in virtue of which a temporary change in the external conditions only gradually influences the light; this naturally makes for steadiness. Another striking feature is that the luminous tube itself, unlike a burning flame, is very transparent. In consequence of this one receives the impression that the tube is much less bright looking perpendicular to its length than when looking from end to end.

High Efficiency Lamps:

Their Effect on the Cost of Light to the Central Station.

By S. E. Doane.

(Paper read before the National Electric Light Association at its Thirty-third Convention held at St. Louis, May 23-27, 1910; abbreviated.)

(*Concluded from p. 556.*)

Table II. presents a summary of the results given in previous diagrams.

Each consumer is assumed to use the same total amount of light after changing to the high efficiency lamps as was used with the carbon lamps.

The logical effect of the high efficiency lamp is to increase the number of small consumers. This means an increase in the proportion of the Central Station expense for labour in connexion with the distributing system and the accounting, &c., which we have classified under "Consumer's Cost." The addition of many new customers will improve the load factor of the station somewhat, as there is no reason to assume that the day load, which is not a lamp load, will not increase with an increase in the number of customers, even though the current consumed at the time of maximum demand does not increase because of the high efficiency lamps.

It is of course obvious that a Central Station could always take care of an increased number of customers without using high efficiency lamps, by increasing the size of the plant, but it is also obvious that the use of the high efficiency lamps will allow it greatly to increase the number of customers served without materially increasing the station and generating investments.

Table 3, which follows, shows, on the basis of the foregoing statistics, what, in a general way, might be expected, when that time in the future arrives, when all of the Central Station customers have changed to the highest efficiency lamps. Of course, we know that the time will never come when every lamp on the circuit will be of the highest efficiency. We, however, can assume any value we may desire, and for the exception still use the table which follows.

TABLE II.

Relative Cost of Serving Various Customers.

Consumer.	Present Intermediate Cost.				Ultimate Cost.		
	Cost Carbon.	Gem.	Tantalum.	Tungsten.	Gem.	Tantalum.	Tungsten.
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
Average	100	91.3	87.0	80.5	75.6	63.8	45.1
Small—Short hr.	100	95.5	93.2	89.8	82.5	73.8	60.6
Small—Long hr.	100	88.1	85.0	77.4	80.0	70.0	54.9
Large—Short hr.	100	92.7	89.1	83.6	71.8	57.8	36.7
Large—Long hr.	100	85.9	78.8	68.2	71.7	57.5	36.3

Consumer.	Kw. maximum demand.	Load Factor.
Average	1.6	11 per cent
Small—Short hr.	0.5	7 ,,
Small—Long hr.	0.5	20 ,,
Large—Short hr.	20.0	7 ,,
Large—Long hr.	20.0	20 ,,

The table is drawn up on the assumption that every customer in the future will have changed to the use of high efficiency lamps. It is anticipated, of course, that between now and the time when this condition will have been reached that each station will have increased its number of customers ; consequently, we have made our assumption to include all percentages, beginning with no increase in customers, and ending with 180 per cent increase in customers, at which time, the station will be again entirely loaded. This table, of course, is drawn up on the further assumption that a customer will not increase the amount of light he uses at peak hours. I firmly believe this assumption is warranted in the case of the domestic user, and that it is warranted in essence in all cases, as I believe that we are rapidly reverting to a condition of somewhat increased light, perhaps, but not to an increase sufficiently great to materially affect this assumption.

I would like to say just a word as to the use of this Table No. 3. Let us assume that a station is adding new customers on the high efficiency basis at the rate of about 9 per cent a year. Let us also assume that a period of time, say three years, elapses before all the present customers will have changed to the highest efficiency lamps. At that time the station will be supplying 130 per cent of its present number of customers, all of whom will be using lamps of the highest efficiency. Running down the left-hand column to 130 per cent and reading across to the final figures at the right, it shows that the average customer at the end of three years will cost the central station 67·8

TABLE III.

EFFECT ON STATION COST AND OUTPUT PRODUCED BY ADOPTION OF THE HIGHEST EFFICIENCY LAMPS.

(Assuming that each Consumer produces the same amount of light with highest efficiency lamps as with the lamps of low efficiency.)

Number of Consumers in per cent of the number supplied at present with low efficiency lamps.	Cost to Station.				Kw-hrs. Consumed and maximum demand in per cent of that with low efficiency lamps.	Relative Cost.	
	Consumer.	Demand	Output.	Total.		* Per Kw-hr.	Per Consumer.
	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent	Per Cent
100 per cent using low efficiency lamps.	14.6	55.1	30.3	100.0	100.0	100.0	100.0
Changed to the following per cent using highest efficiency lamps.							
100	14.6	55.1	10.8	80.5	35.7	225.0	80 5
110	16.1	55.1	11.9	83.1	39.3	212.0	75.5
120	17.5	55.1	13.0	85.6	42.9	200.0	71.4
130	19.0	55.1	14.1	88.2	46.4	190.0	67.8
140	20.4	55.1	15.1	90.6	50.0	181.0	64.7
150	21.9	55.1	16.2	93.2	53.6	174.0	62.1
160	23.4	55.1	17.3	95.8	57.2	168.0	59.8
170	24.8	55.1	18.4	98.3	60.7	162.0	57.8
180	26.3	55.1	19.5	100.9	64.3	157.0	56.1
190	27.7	55.1	20.6	103.4	67.9	152.0	54.4
200	29.2	55·1	21.6	105.9	71.4	148.0	52.9
210	30.7	55.1	22.7	108.5	75.0	145.0	51.7
220	32.1	55.1	23.8	111.0	78.6	141.0	50.4
230	33 6	55.1	24.9	113.6	82.2	138.0	49.6
240	35.0	55.1	26.0	116.1	85.7	135.0	48.4
250	36.5	55.1	27.1	118.7	89.3	133.0	47.5
260	38.0	55.1	28.1	121.2	92.9	130.0	46.6
270	39.4	55.1	29.2	123.7	96.5	128.0	45.8
280	40.9	55.1	30.3	126.3	100.0	126.0	45.1

* Please do not confuse this with the output cost per kw-hr. which remains practically constant throughout.

per cent as much as he does to-day—even though he uses high efficiency lamps and consumes only about one-third as much current. We find by reference to the sixth column that the actual kw. output in such case will be only 46 per cent of what it is to-day.

Some one has asked me, upon reading this paper, why we did not deal with other factors in the cost of operating a central station than that of lighting, and my reply was that lighting was the only subject upon which I considered I had any right to address this Association. This 46 per cent of present output indicates only the current used for lighting. I have no idea there is any station whose load is so purely lighting that when the 30 per cent additional customers have been obtained they will not actually have a greater output than 46 per cent of that at present, due to the day load and the power load.

This table clearly shows that those costs which we have classed as the consumer's costs, which are the costs per customer for distributing the current generated, are the costs which concern the Central Station to a constantly increasing extent. The investment in meters and the length of line necessary to run to reach a customer, the location of meters to facilitate reading, and details of this character, will be of considerably greater importance to the station man than the efficiency of the generating apparatus.

It has been suggested to the writer that the customer's cost can be reduced 50 per cent when several ends have been accomplished, among which is the universal adoption of a cheap meter, a current limiting device, or something equivalent to either, or both, &c. This is a matter of speculation, but it is interesting to observe from the table that such a 50 per cent decrease would allow the Central Station to carry 180 per cent more customers with the same gross cost, at which time the cost per kw. would be no greater than at present, and at which time the total average cost per customer (please do not confuse this with the customer's component of the fixed costs), on the basis of our assumption, would be decreased to 36 per cent of the present total average cost per customer.

It is most interesting to note that when a station has added 80 per cent more customers its total cost will have again reached the present cost, but the cost per kw.-hr. will be about 60 per cent greater than at present. It is most interesting, furthermore, in showing that even when the station again becomes fully loaded, the cost per kw.-hr. will be about 25 per cent greater than it is at present.

The effect of the high efficiency lamp has been to modify profoundly commercial practice. The possibility of these lamps being made more efficient as the weeks pass makes it necessary for the Central Station to adopt policies, programmes, and methods which not only will take care of the present high efficiency lamp situation, but which will provide for any increase in efficiencies in the weeks, months, and years to come.

Ductile tungsten wire has been produced, and it is a most reasonable expectation that the high-class Tungsten filament lamps ultimately will be hardy and capable of satisfactory employment in houses or elsewhere where the supposed fragility has been argued against them. Every customer on a Central Station circuit will ultimately purchase and use lamps of this character.

Never in the history of our industry has there been the opportunity which now presents itself to the Central Station for increasing the number of its customers, decreasing the cost to each of them, and increasing profit to itself, through the use of the high efficiency lamps.

Some Notes on Opal Shades and Screens for Gaslighting.

By An Engineering Correspondent.

There are few matters more closely connected with illuminating engineering than the correct choice and use of shades and reflectors, and it occurred to the author that a few remarks dealing with some of the opal shades at present constantly used in connection with gas-lights would be of interest. This subject was recently dealt with, among other matters, by Mr. J. G. Clark,* and it is certainly one that deserves attention. It may be admitted that there is still much to be decided in connection with the proper use of these shades. With

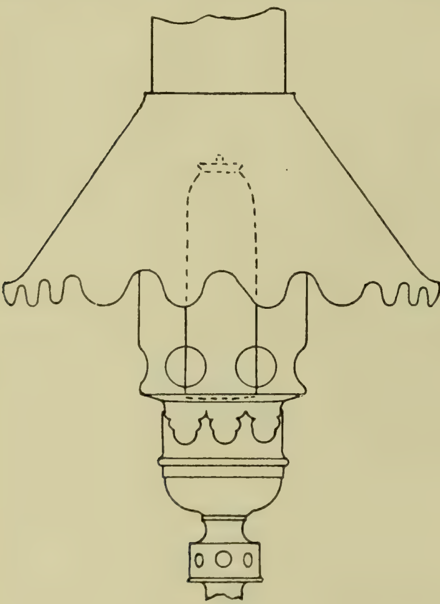


Fig. 1.

the interesting questions affecting artistic design and decorative appliances it is not proposed to deal in this article. But there are certain anomalies in the every-day use of the ordinary shades which must strike anyone passing along the streets by night.

The object of a shade is usually two-fold. It should screen the eyes of the observer from anything in the nature of objectionable glare from the source of light, and it should also assist the functions of the source by concentrating the light where it is mainly needed. A great deal has been said recently about the necessity of screening naked lights of intense brilliancy. Several independent decisions have been arrived at that the intrinsic brilliancy of sources exposed to the eye at moderately close quarters should not exceed about $2\frac{1}{2}$ candles per square inch, and it might be suggested that in shop-windows, where any bright surface exposed among the goods is specially distressing, this rule might be followed with advantage, especially as it is not a difficult con-

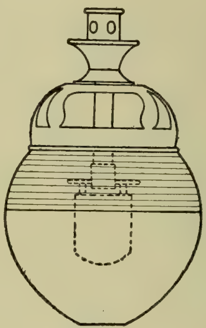


Fig. 2.

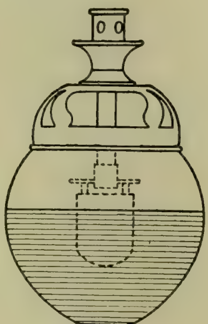


Fig. 3.

dition to comply with in the great majority of cases. Some writers, it is true, have expressed the view that even this figure is too high, but if the above reasonable figure was taken as a basis for the present, it may be safely said that the appearance of most shop-windows would not suffer but would benefit as a result.

Special comment has been made on the great intrinsic brilliancy of the metallic filament, but there are few artificial sources of light in use to-day which do not exceed the above limit, and in the case of which shading is not desirable for shop-window illumination.

* *Journa of Gaslighting*, April 26, 1910.

In many instances it is not so much that the design of a shade is fundamentally wrong as that it is misused. Take, for example, that shown in Fig. 1, which is a very common form in gas-lighted shop-windows.

Used in this way a part of the mantle can almost always be seen by people looking into the window. All that is needed to remove this objection is to bring the shade somewhat lower down, so that the mantle is always out of the line of sight. On the other hand, the shade, as it stands, might answer better if used low down, for desk lighting for example, so that the mantle was properly covered.

The same remarks might be applied to the shades shown in Figs. 2 and 3. One often sees two such shades, identical in all respects except that the upper portion is obscured in one case and the lower part in the other, used under exactly similar circumstances. Yet presumably two such entirely different arrangements cannot both be right. In Fig. 2, for example, the obscured portion is apparently intended to act as a reflector, and it has certain merits from this standpoint. Moreover, though the loss of light in absorption may be considerable, it has the advantage of allowing a small percentage of light to emerge upwards, which opaque reflectors do not. On the other hand the mantle is left only very imperfectly screened. In this shade, therefore, the idea of screening seems to have been lost sight of, the main conception of the shade being to reinforce the light downwords.

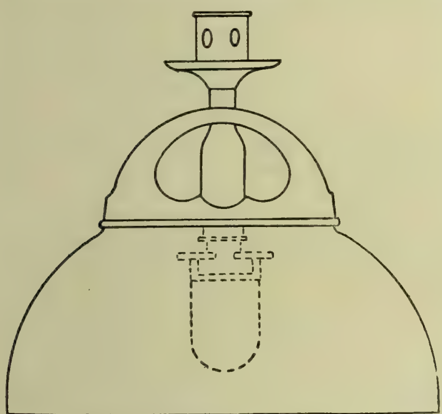


Fig. 4.

In Fig. 3 we see exactly the opposite idea. The obscuration on the lower part of the globe will protect the eyes from the direct rays of the mantle; on the other hand it is inevitable that a considerable amount of light would be thrown upward, while the downward component would be reduced.

It is quite possible that in certain circumstances both these devices might be found satisfactory. This, however, is not always appreciated by those into whose hands they fall, and, as stated above, they appear to be often used indiscriminately.

What is probably a much more satisfactory fixture in the shop-window is the type shown in Fig. 4. The cup-like opal reflector should help to throw the light downwards and, unless used at a very high level, it should also serve to screen the mantle.

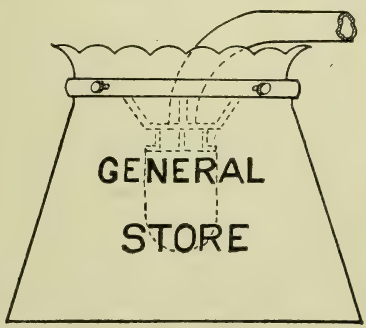


Fig. 5.

One more type of shade worthy of notice is that shown in Fig. 5. In this case it has apparently been recognized that the downward component of the inverted mantle is already sufficiently strong and does not require accentuating. The main object of the shade, therefore, is to screen the mantle and distribute the light, but advantage has also been taken of the illuminated surface provided to put in the name of the firm. Naturally the shades could be effectively used for other notices regarding goods, special sales, &c.

It may be suggested that many shops lighted by shades of this kind would be the better for a little expert supervision. The attitude of gas companies towards consumers has admit-

tedly become much more painstaking of recent years, and a great deal more trouble is now taken to ensure that the gas supplied is really well used. In many such cases a little advice as to the kind of shade to be used, and its position in the window, would doubtless be welcome. The matter may also be commended to the notice of gas-fitters. There seems to be a general recognition that the education of fitters in the details of the arrangement of lights is a matter which must be dealt with in the near future. For example, in the first number of a newly issued publication devoted to gas light, distribution, and maintenance, emphasis is placed on the insufficiency of really well-trained fitters. In this connection it is asked :—

"Is it not a fact that if 500 men were required to manage small gas-works they could most easily be obtained. But, were this number of fitters required to take charge of the fitting departments of comparatively small works, it would be difficult to find even a dozen men having the necessary qualifications. A gasfitter must not only be trained in his handicraft, but in the arrangement of light, and must be able to suggest appropriate lighting schemes for all the various requirements of customers."

There can be no question that the gas industry could only benefit by a more general knowledge and appreciation of the simple rules of good lighting among those accustomed to installing gas fittings and shades. Only some of the commonest types have been mentioned in this article, the more elaborate designs being left for subsequent discussion.

CORRESPONDENCE.

The Distribution of Energy in the Spectrum of the Moore Light.

DEAR SIR,—I have followed with great interest Dr. Coblentz's recent series of articles dealing with the distribution of energy in the spectra of artificial illuminants. They serve admirably to bring out the differences in the nature of the radiation from the various sources examined.

There is, however, one source of light which does not seem to have been examined, and regarding which much might be learnt by a study of the distribution of energy—namely, the Moore light. I understand that the carbon dioxide tube is claimed to give a spectrum closely resembling that of sunlight, and a comparison of the nature of the energy curves in the two cases might yield most interesting results. In addition one would like to know what kinds of invisible energy are radiated in this case and how the luminous efficiency compares with that of other artificial sources of light. I have seen it stated that nearly a third of the energy produced by luminescent mercury occurs as ultra-violet light (though much of this is degraded into heat by the encircling glass tube), and one might naturally suppose that oscillatory discharge through gases might generate energy of the same description.

One thing strikingly brought out by Dr. Coblentz's curves is the radical difference in distribution of energy throughout the spectrum in the case of luminescent and incandescent materials respectively. Presumably the Moore tube owes some amount of its light to both these processes, though one would suppose that incandescence predominated, seeing that an approximately continuous spectrum seems to be obtained. I am, &c.,

I. WANTERNO.

Short Notes on Illuminating Engineering.

From all Sources.

Railway Carriages and Glare.

WHAT can we think of a railway lighting installation which exposes absolutely unshaded filaments of high intrinsic brilliancy on practically the same level as the heads of the unfortunate passengers in the coach ? For, let it be remembered, not many of the lamps in City and South London coaches are perched up in the roof : the majority appear to be fixed on the side of the coach under the roof, with the result that to look anywhere except on the floor is a task which would be more pleasant did one possess a pair of blue glasses. And this is 1910, and an Illuminating Engineering Society has been running for over twelve months !

Electrical Industries, Sept. 7th.

Theatre Exit Lamps and Safety Precautions.

RELIABILITY is clearly of first importance in the source of light used for exit lamps in theatres, &c. It is desirable that such lights should be independent of the main lighting, so as to be unaffected by a temporary breakdown. For this reason gas has often been employed in such cases, so as to be independent of a failure in the electricity supply. The value of dissolved acetylene for "emergency lighting" in theatres has also been pointed out, and there are on record cases in which a special separate circuit, with the wires run through fireproof steel tubes to a battery of accumulators in the basement, has been adopted.

A recent number of *The Electrical World*, however, calls attention to an installation which is shortly to be fitted in a Chicago theatre, with a local storage battery for each lamp, thus making the equipment at each exit self-contained and complete in itself ; no external piping or wiring is required. As a further precaution against interruption of light, the exit signs will be provided with two lamps, the second of which is automatically switched on if, from any cause, the first lamp goes out. This system is stated to be already in use at Berlin.

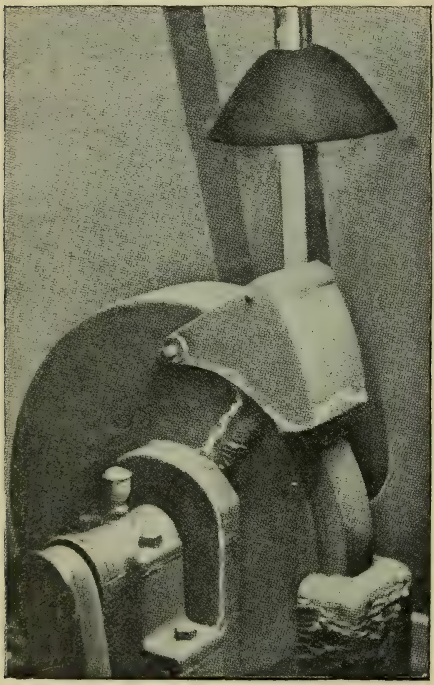
An Automatic Acetylene Lighthouse.

THE Harbour of Guernsey has the distinction of possessing an acetylene lighthouse which is worked automatically, thus dispensing with the services of an attendant. It is stated in the September number of *The Acetylene Journal* that a lighthouse at the entrance to the harbour has long been a necessity, but lack of funds and the fact that the rocks were too small for an ordinary lighthouse, prevented it from being built.

These difficulites have, however, been overcome in the new lighthouse, which is equipped with an acetylene lamp system, and works automatically, according to the weather and the season, thus largely reducing the operating expenses. If this installation proves successful, it should lead to the adoption of the system in many cases where lighthouses are dangerously isolated, and where the shipping of supplies in time of storm is sometimes impossible.

Localized Lighting of Machines.

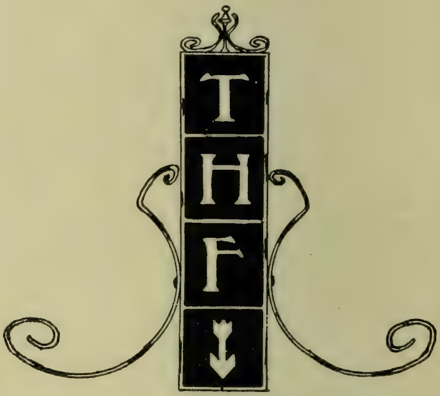
Reference was made in our last number to the importance of localized lighting for machine tools, &c., in factories. The illumination of an emery wheel, as shown in the accompanying illustration, is a case in point. An 8 candle-



power lamp, fitted with a Holophane steel reflector concentrates the illumination on the face of the wheel; and screens the source itself from the eye of the worker. This is an important item in the case of work of this kind, as the ability of the workman to turn out good work depends upon his being able to see exactly what he is doing without being distressed by the glare of adjacent bright lights. In order to provide for the lighting of the edges, the fitting is capable of a slight lateral movement on a sliding arm, enabling the light to be thrown on either face as desired. It is pointed out in *Industrial Engineering*, from which the illustration is taken, that a saving of 50 per cent is secured at once by this arrangement when compared with a bare 16 candle-power lamp such as would probably be used in old-fashioned shops; and this quite apart from the great increase in the effectiveness of the lighting, and convenience to the operator.

Illuminated Signs for Cab Calls.

The latest adaptation of the electric sign, as described in *The Electrical Field* for August, is not an advertisement device, or, strictly speaking, a notice. It serves to call a cab to the door of an hotel when desired, without



the ear-piercing whistle which we have endured for so long. The sign carries three letters, "T," "H," and "F," indicating "taxicab," "hansom," and "four-wheeler" respectively, and an arrow pointing downwards to the place where the cab is required. Each letter is illuminated by a 50 c.-p. lamp, and three switches for control are placed in the hotel entrance to be operated by the hall porter when required. The arrow is illuminated at the same time as the particular letter selected. A sign 8 in. wide by 2 ft. 6 in. deep, of the type illustrated here, is in use over the entrance to the Carlton Hotel, and we understand that additional ones are shortly to be provided.

The Contractor and the Sale of Illumination.

I AM convinced that excellent business awaits the contractor who will go round his old customers and sell them a little illuminating engineering. Brisk trade has been done in new lamps for old—why not in new illumination for old? Any one who likes to look will find in hotel after hotel, shop after shop, restaurant after restaurant, house after house, the simplest principles of sensible lighting violated in the most thoughtless way. If I were not an old man, I would like to start a business which would have no other object than making money by overhauling systems of illumination. Thousands of householders and shopkeepers could be given better light by a few simple changes in equipment.—*Electrical Industries*, September 7th.

Colour Contrast and Background.

ANYONE with experience of photometry is aware of the difficulty of causing the dividing line between the photometrical surfaces to disappear completely. In order that this may be the case it is not only necessary that the dividing line should be sharp and clean, but also that the two surfaces should be at once equally bright and of the same colour. The tendency to brightness in advertisement signs is largely due, in all probability, to the instinct for creating a vivid contrast in illumination; more recently a liberal use has been made of colour with this object, for example, in the illuminated signs now installed on some of the underground railways.

It is, however, not always appreciated how difficult it is to distinguish, at some little distance, an object which has exactly the same tint as its surroundings. In a fairly weak light, objects of this kind can disappear with amazing completeness. An interesting illustration of this principle is provided by the recent experiments with uniforms of different materials in the German army, the idea being to secure the tint which would be the least visible against the normal summer and winter background. As a result a kind of grey-green was adopted. It is said that in the recent manœuvres a section of one of the contending armies managed to delude the scouts of the enemy by virtue of this effect. They erected sham fortifications which could easily be seen from above, while the men, in another part of the field, in their grey-green uniforms, could not. Consequently the enemy's airship, hovering overhead, was completely misled as to their whereabouts, and a very successful ambuscade was the result.

Moving Pictures on the Tubes.

ACCORDING to *The Morning Leader*, an interesting experiment is to be made on the Great Northern and City Tube Railway (London). The suggestion is that a series of appropriate pictures should be placed at intervals along the tube so that, when seen in rapid succession by the passengers in the moving train, a cinematographic effect is produced. The arrangement in fact is to resemble in principle the ordinary cinematograph entertainment, except that the observer moves and the pictures in this case are stationary.

The method is to be adopted for advertising purposes, the series of pictures being from 300 to 600 ft. long. They will be illuminated partly by the lights of the passing train and partly by special lamps which are automatically brought into action as the train passes. They will be placed only in those parts of the tube where the speed of the train approaches 15 miles an hour; this, it is thought, will be sufficient to enable the true cinematographic effect, without abrupt discontinuity, to be obtained.

Of course, it is recognized that there is the possibility that the living pictures so produced may not please all travellers. But in this connection it is stated that "The verdict rests with the public."

Lighting a Baseball Ground.

Another example of artificial illumination of athletic arenas is described in a recent number of the *Electrical Review* of New York, namely the newly opened baseball ground in Chicago, which is illuminated by a series of flame arc lamps. A number of different games, such as baseball, football, and lacrosse, seems to have been played with success by artificial light.

The problem of lighting a large arena like this, in such a way as to suit the needs of both players and spectators, is a somewhat difficult one. A high general illumination is wanted to enable the spectators to watch the game. It is also essential in such games as those enumerated above that the ball should be illuminated and visible to players and spectators when it rises to a considerable height; yet the lights must be arranged so that there is no inconvenient glare when the eye looks upward in trying to follow the ball. This last compromise seems to have been mainly attained by the use of approximately horizontally directed searchlight beams, so that the light, striking sideways, would illuminate anything in the area covered and yet would never enter the eyes of the people below.

Other lights, placed very high up, were utilised to illuminate the arena. The ground illumination is said to have exceeded 3 foot-candles, and the players are reported to have declared that the inconvenience caused by looking at such distant lights as were inevitably visible to the eye was at least less pronounced than would have been the case in ordinary bright sunlight.

The Difference in the Play of Shadow by Natural and Artificial Illumination.

The illustration on the opposite page (for the use of which we are indebted to the courtesy of the Editor of the *Architectural Journal*), presents another interesting example of the difference in the distribution of daylight and artificial illumination, as ordinarily used.

The figure shows a corridor in the building devoted to the Bristol Public Library. It is satisfactory to note, in passing, that the electric lamps have in this case been provided with a covering shade intended to screen the filament from the eyes of those passing underneath. It will be observed that the daylight illumination is exclusively derived from the row of windows on the left, whereas the artificial sources are located at the summits of the arches. Naturally one would imagine that this would give rise to quite different conditions of shadow and distinct architectural impressions, though the light tint of the surroundings might in this case help to smooth away such differences.

The question must arise in the case of many buildings of architectural importance whether the design is intended to be regarded solely from the standpoint of daylight effects. The lighting of churches will occur to our readers as an extreme example of this. It will be recalled, however, that Mr. Leonard Stokes, the President of the Royal Institute of British Architects, has put on record his opinion* that the main thing to be considered in lighting such an interior is not the effect on the architecture but the needs of the congregation.

* *Illum. Eng.*, Lond., Feb., 1909, p. 136.

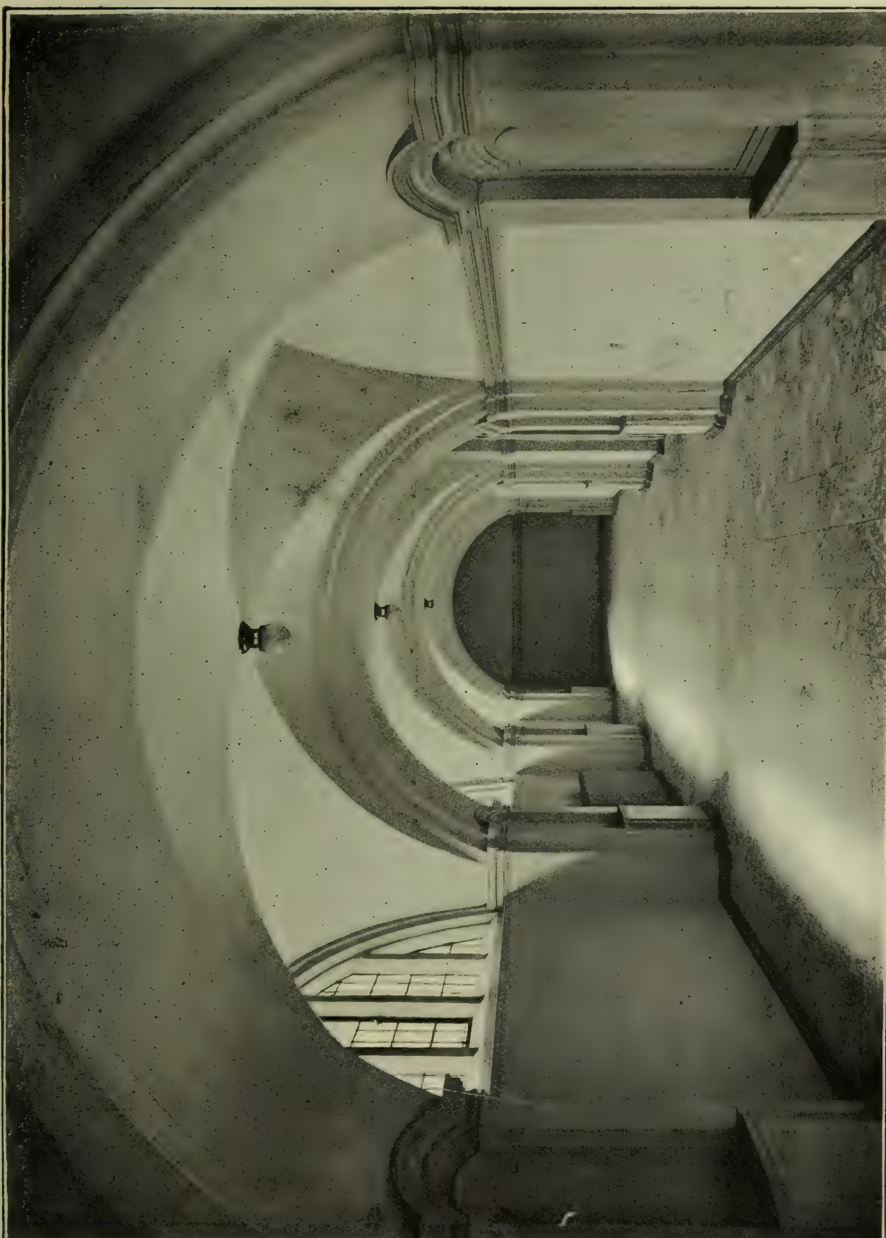


FIG. 1.—Daylight and Artificial Lighting of Corridor in the Bristol Public Library. By the courtesy of the Editor of *The Architectural Journal*.

Church Lighting Fixtures.

Below will be found a view of the baptistry of the small church of St. Barnabas, Shacklewell, London. The architect is Prof. C. H. Reilly, M.A., A.R.I.B.A., of Liverpool, to whose courtesy, as well as to that of the Editor of *The Architects' and Builder's Journal*, we are indebted for permission to use this illustration.

The church in question is referred to by our contemporary as exceptionally interesting both constructionally and from the standpoint of architectural design, but the arrangement of the lighting fixtures in the part of the church here shown struck us as being worthy of comment.

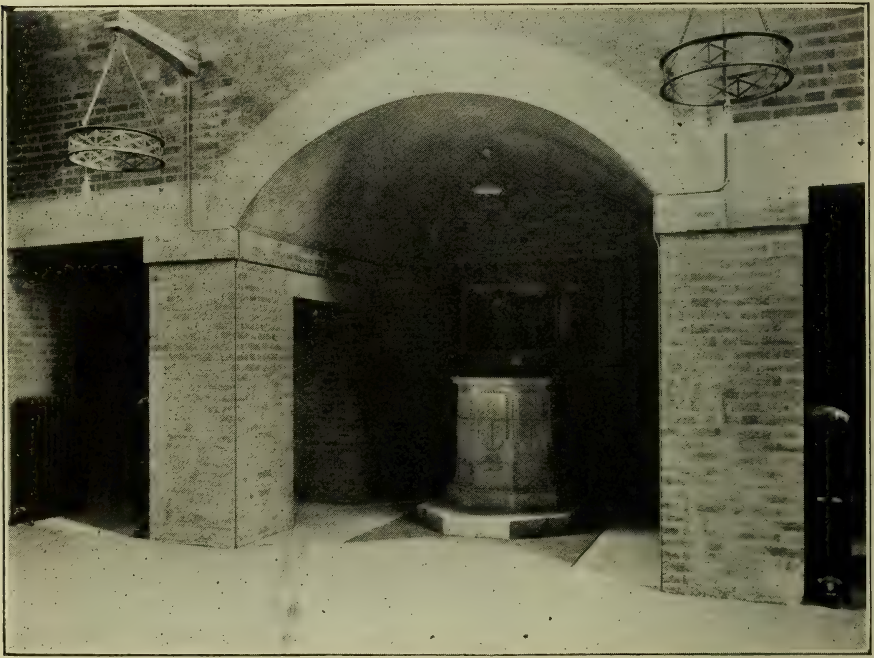


Fig. 1.—Portion of Church of St. Barnabas, Shacklewell, London.
By the courtesy of *The Architects' and Builders' Journal.*

It will be noted that two ring-shaped fixtures are to be seen on either side of the baptistry, presumably a modern development of the old chandeliers of this kind, round the circumference of which small fat and oil lamps were placed at frequent intervals. Such a fixture, therefore, is associated with the traditions of the past, and one would imagine that the adaptation of the design to electric lighting would call for nice discrimination in the choice of lamps and fittings in order to avoid a sense of incongruity. Presumably the use of the metallic filament lamps shown hanging from the ring without shades is merely temporary.

We should also have supposed that a form of fixture less purely utilitarian than the simple opal shade and ceiling rose shown might profitably have been utilized in the recess, but no doubt economy was a ruling consideration. It would be helpful to engineers if architects would interest themselves to a greater degree in this question of fixtures for churches. There seems a need for more definite rulings as to what is fitting in such cases, and more complete directions as to the best methods of utilizing such comparative innovations as electric light in interiors of architectural interest.

TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

The Westinghouse "Silica" Lamp.

In these columns references have frequently been made to the development of the quartz tube mercury lamp. It has been stated that by the aid of a small tube of quartz, which is able to stand a much higher temperature than an ordinary glass tube, a much more efficient form of lamp can be obtained, and there is the incidental advantage that the colour of the light is much improved.

A lamp constructed on these lines may now be seen on view outside

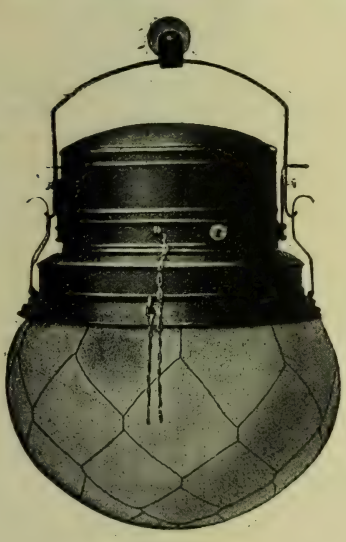


Fig. 1.

the offices of the **Westinghouse Cooper Hewitt Company** (151–152, Great Saffron Hill, Holborn Circus, London, E.C.). It is stated to yield 3,000 candle-power. The most striking thing about its appearance is that the light, unlike that of most arc-lamps, appears to be distributed over a uniformly illuminated globe 14 in. in diameter, with the result that a light of low intrinsic brilliancy, giving very "soft" shadows, is obtained. The colour of the light is bluish white, the peculiar tint characteristic of the Cooper Hewitt lamp being here much less noticeable.

The general appearance of the lamp will be gathered from Fig. 1, the component parts being shown in Fig. 2. The overall length is 23 in. The outer opal globe contains the small quartz tube A, which is started, on the application of the supply P.D., by an eletromagnetic rocking device B, and contains luminescent mercury vapour. After the tube has been drawn up and the lamp started the current flows through the coil i

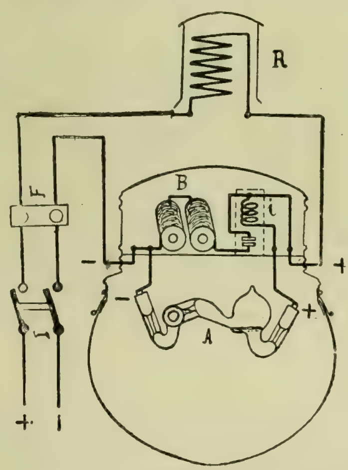


Fig. 2.

which cuts out of circuit the rocking solenoid B. There is also a steadying resistance, R, in series with the tube. The 250 volt lamp is listed to consume about 3·5 amperes and to give a mean hemispherical candle-power of over 3,000 c.-p., at a specific consumption of 0·25 watts per c.-p., inclusive of the drop in the resistance (about 100 watts). Fig. 3 shows the actual distribution of the light, the maximum of 4,500 c.-p. occurring at 65 to 70 degrees.

It will be observed, moreover, that the light is distributed over a wide angle in the lower hemisphere.

Besides the advantages of low intrinsic brilliancy and high efficiency mentioned above, there are other merits claimed for the lamp. It is pointed out, for example, that there is no need for the recarboning and constant attention which arc-lamps require, and this, quite apart from the saving in cost of electrodes and maintenance, is an item to be considered by shopkeepers and others more or less unfamiliar with electrical details. There is also no danger of rapid obscuration of the globe by the deposit of fumes. It is stated that the quartz tube itself is practically indestructible, and that the candle-power of a lamp only decreases very gradually with life. Although a life of 1,000 hours is guaranteed, the average life is said to approach nearer 2,000 hours, and a representative of *The Illuminating Engineer* was informed that 14 of these lamps in Paris had actually burned without attention for over 10,000 hours. When, however, a tube eventually fails through deterioration of the vacuum it can be readily and cheaply repaired. It may be added that the tube itself is by far the most expensive item, being half the entire cost of the lamp.

Another point on which stress is laid is the steadiness of the lamp, and the absence of any feeding mechanism. By a special contraction of the neck of the tube the lamp is rendered independent of any ordinary fluctuation in voltage, and it is stated that it will operate equally well should the pressure rise or fall even as much as 10 per cent.

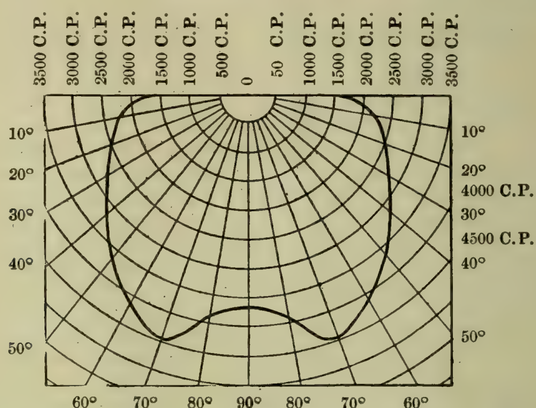


FIG. 3.

A table is presented by the company showing the comparative economy of this lamp and various flame arcs. According to this, assuming that the quartz tube only lasts the guaranteed time of 1,000 hours, the total running cost per 1,000 (hemispherical) c.p. hours works out to about 1·3 pence with energy at 3*d.* per k.w.

Tantalum Lamps, Holophane Reflectors, &c.

Messrs. Siemens Brothers Dynamo Works, Limited, of Tyssen Street, Dalston, London, N.E., inform us that they will shortly be placing on the market a series of 18 new prismatic reflectors of the HOLOPHANE type, specially adapted for use with "Tantalum" lamps. These reflectors, it is stated, will be of novel design, and will range in price from 3*s.* to 12*s.* each; the larger and more expensive sizes will be very suitable for Messrs. Siemens' new "One-watt" 100 c.-p. lamps.

Our attention is also drawn to the publications of the firm in which their various well-known posters are reproduced in small size. The firm are also supplying a five-coloured card giving reduced facsimiles of all types of literature which they overprint in quantities, with the contractor's name and address, free of charge. This includes postcards and three or four types of adhesive labels supplied for attaching to correspondence. Those interested are invited to apply to the publication department of the firm at the above address.

"HANDSHIELD" FITTINGS.

We have received from the **British Central Electrical Co.** (17, Hatton Garden, London, E.C.), a list illustrating their "HANDSHIELD" fittings, which

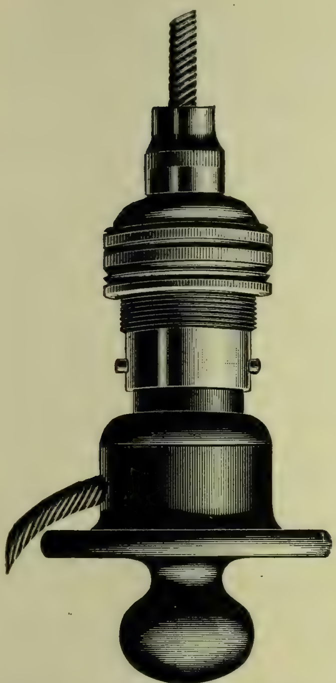


FIG. 1.—"Handshield" Plug-fitting.

have been designed to meet the new Home Office Regulations. It will be seen from the illustration of an adapter which we reproduce here that there is a substantial insulated flange between the handle and the point at which the flexible wires enter; this serves the double purpose of protecting the user from shock, and rendering the flexible less liable to damage.

INCANDESCENT OIL AT BRUSSELS.

We are informed that the exhibit of safety incandescent oil lamps of the "BLANCHARD" type, manufactured by the **Gas Economising and Improved Light Syndicate, Ltd.** (138, Leadenhall Street, London, E.C.), was awarded a gold medal at the Brussels Exhibition.

THE "QUARTZLITE" LAMP.

Yet another type of lamp recently introduced which employs a small quartz tube containing luminescent mercury is the "QUARTZLITE" lamp made by the **Brush Electrical Co.** (1, Kingsway, London, W.C.). The lamp is stated to be made for direct current circuits from 100 to 150 and 200 to 250 volts, the rated candle-power in the two cases being 1,800 and 2,500 respectively, and the average efficiency claimed 4 candles per watt. In this case also the quartz tubes are guaranteed to last for over 1,000 hours.

This lamp is specially recommended for use in illuminating harbours, docks, shipyards, and other open spaces. Its general appearance will be understood from the illustration above.

The Association of Engineers-in-Charge.

Annual General Meeting.

At the Annual General Meeting of the Association of Engineers-in-Charge, the Chairman, Mr. A. E. Penn, was able to give a very satisfactory account of the Association from all points of view, and the statement of accounts presented by the Hon. Secretary, Mr. Hy. Capsey, was well received and adopted unanimously.

The whole of the retiring Councillors, the Auditors, and the Hon. Secretary (Mr. H. Capsey), Treasurer (Mr. H. Swann), and Librarian (Mr. J. Ryan) were re-elected, and a most cordial vote of thanks was accorded these officers for their past services; a similar compliment was also paid to Mr. W. T. Pickett and Mr. W. H. Ball, Chairman and Hon. Secretary respectively of the Social Committee, for their untiring efforts to promote the social welfare of the Association.

The Chairman, in returning thanks for their re-election, announced that the President-Elect was Capt. H. Riall Sankey, R.E. (retired), M.Inst.C.E., &c., whom they all so well knew and held in such high esteem, and that when the time came for taking up his position they would find him prepared with a most excellent address. Their duty to Capt. Sankey was to make his year of office equally as successful as that they had enjoyed under the Presidency of Mr. Adams, whose expressed desire was that it should be excelled if possible.

The meeting terminated after sundry matters were disposed of under general business, and a reference to the forthcoming visit to the Naval Exhibition on the 24th, and the paper to be read on that occasion, particulars of which are also given.

The Northampton Institute.

We have before us the programme of the Northampton Institute, Clerkenwell, London, E.C., for the coming session. We note that, as on previous occasions, a course of lectures dealing with 'The Production and Measurement of Light' is to be included in the syllabus, and we understand that the work in connexion with technical optics is to be extended. A feature of the Institution is the new generating station, which has just been completed, at a cost of £6,000, for the benefit of the Electrical Engineering Department, and which will be formally opened on the 12th of October by the Chairman of the London County Council. It will also be recalled the position vacated by Dr. C. V. Drysdale in this department is to be filled by Mr. F. M. Denton, whose appointment we announced some time ago.

Illuminating Engineering Society.

(Founded in London, 1909.)

PAPERS FOR NEXT SESSION.

It is anticipated that the first two papers of the coming session will be as follows:—

THE PRESENT STATUS OF GAS LIGHTING. By Mr. F. W. Goodenough.

RECENT PROGRESS IN ELECTRIC LIGHTING. By Prof. E. W. Marchant.

The date provisionally fixed for the first meeting is **Tuesday, November 8th**; further information will be sent to members shortly.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

THE chief items of the past month, in connexion with illuminating engineering, are the papers read in connexion with the Congrès International des Maladies Professionnelles and the Royal Sanitary Institute, to which, however, reference is made elsewhere in this number. The papers by **L. Gaster, F. Massarelli, Dr. F. Terrien, Dr. A. Broca,** and others at the former gathering, dealt with the hygiene of eyesight and the application of sanitary and hygienic principles of the LIGHTING OF FACTORIES. The paper by **J. Darch** read at the Royal Sanitary Institute Congress, is reported in a number of papers; it lays stress mainly on the desirability of shading sources of light and making use of reflection from light-tinted surfaces.

A number of interesting papers also appear in the American journals. An article by **Dr. F. A. McDermott** (*Popular Science Monthly,* August) deals with PHYSIOLOGIC LIGHT in a popular manner, discussing the phosphorescent effects of various insects and decaying materials and the possibility of eventually making use of them in practice. Several contributions deal with the LIGHTING OF PICTURE GALLERIES, a general diffused illumination being recommended.

The subject of STREET LIGHTING is also well to the fore. **L. Bell** (*Electrical Review,* N.Y., September 10) gives a summary of recent progress in this direction, while the Westminster decision is still the subject of much comment in the technical press of Great Britain. Another interesting problem is the ILLUMINATION OF BOWLING GREENS, which is dealt with by **W. E. Rhodes** in *The Electrical Review* (London) of September 2nd; this contribution would be rendered more interesting, however, by further details of the intensity of illumination and the method of shading the eyes of the players.

The LIGHTING OF SCHOOLS is considered in a general article in *The Electrical World* (September 8), in which stress is laid on the many purposes for which light is needed besides merely lighting the desks. Insufficient attention is often paid to the black-boards, for example. We are still in want of more precise data as to the intensity of illumination required to enable diagrams to be seen at some little distance. An interesting abstract is given in *The Electrical Review,* N.Y. (September 10), of a paper dealing with the lighting arrangements in the studies of the cadets at the American Naval College at Annapolis. It is interesting to find that the authorities are taking this matter up, and that the paper in question (which originally appeared in a magazine devoted to naval matters) was written by an engineer and medical man in co-operation. The *Oesterr. Ungar. Installateur* for September 17 publishes an interview with **Prof. W. Wedding,** who reviewed the progress in different illuminants and tried to suggest the purposes for which each is best suited. He also lays stress on the need for improvements in methods of producing a mild general illumination rather than very powerful concentrated sources.

Turning to articles on photometrical subjects, mention may be made of the contribution by **Dr. E. P. Hyde** on the PHYSICAL LABORATORY OF THE NATIONAL ELECTRIC LAMP ASSOCIATION (*Electrical Review,* N.Y., September 10), in which an account is given of the equipment and work to be carried out under his supervision. **Dr. H. E. Ives** (*Electrical Review,* N.Y., September 10) reviews the STATUS OF HETEROCHROMATIC PHOTOMETRY. After pointing out the inherent and inevitable difficulties in the subject he comes to the conclusion that some general agreement on a more or less arbitrary method, such as the use of tinted glasses recently recommended by the Bureau of Standards, is desirable. **C. C. Paterson** and **H. Rayner** (*Electrician,* August 26) give some details of COMPARATIVE TESTS ON GLOWLAMPS undertaken at the National Physical Laboratory of the Bureau of Standards, the object being to see what order of consistency between the results of the two laboratories was possible. Favourable results are recorded regarding short life tests at a voltage above the normal.

Lastly mention should be made of an interesting article by **W. T. Vivian** and **G. W. Huey** (*Electrical World,* N.Y., August 18), who describe experiments on a PORTABLE PHOSPHORESCENT PHOTO-

METER. The idea is to replace the usual small glow-lamp and accumulator by a surface coated with phosphorescent paint, but there are several difficulties. For example, the light given out decreases rapidly after exposure, and the brightness of the surface depends on the temperature so greatly that it was found necessary to keep the screen at the temperature of melting ice.

ELECTRIC LIGHTING.

One of the most interesting articles during the past month has been the interview of **Dr. Cooper Hewitt** which appears in *The Electrical Review* of New York (September 10). This inventor claims to have produced a kind of reflector, which when used with mercury vapour lamps supplies the missing part of the spectrum, and yields a quality of light closely resembling daylight. The method consists in coating a white diffusing surface with various materials, which become fluorescent in the light of the mercury lamp, converting the short wave radiation into light of reddish tint.

Electrical journals in Great Britain contain particulars of the "SILICA" AND "QUARTZLITE" LAMPS, recently put on the market in this country, both of which are examples of mercury vapour lamps utilizing the new small quartz glass tube. A specific consumption of about 0·25 watts per candle is claimed, and the light is stated to be much whiter than that of the mercury vapour lamp. The tube is guaranteed to last without attention for over 1,000 hours, though some tubes have lasted much longer.

We also note a description (*Electrical World*, September 1) of a method of artificially lighting arenas so that baseball and other sports can be carried out by artificial light. It is said that players experienced no difficulty in catching the ball, &c., and that games were played out with a speed which would be considered favourable under daylight conditions; it is therefore claimed that, in spite of the bright illumination, the interference due to glare could not have been more serious than in the daytime.

A number of articles dealing with metallic filament lamps are to be recorded: thus **J. S. Merril**, in the *Proceedings* of the American Institute of Electrical Engineers for September, gives very full data regarding life tests, and presents the usual curve illustrating the properties of such lamps. Some micro-photographs are also given, showing how various filaments change in the course of their life.

Among other articles dealing with the technicalities of the metallic filament lamp, we may note that of **G. B. Barham** (*Electrical Times*, September 1), who describes different methods of making joints between the filament and the leading in wires. The use of TUNGSTEN LAMPS FOR STREET LIGHTING also receives attention in *The Electrician* (September 23) and other papers, the experiences of a large number of central station engineers and others being quoted. The *Zeitschrift für Beleuchtungswesen* refers to the "Wotan lamp"; this name is given to lamps in which drawn tungsten is employed, and is said to be derived from the words Wolfram and Tantalum, the idea being that the efficiency of a tungsten filament is combined with the strength of a tantalum one.

Finally we may mention the serial contributions of the *Zeitschrift für Beleuchtungswesen* dealing with new types of arc lamps, and a descriptive article in the *Revue des Éclairages* describing the Moore lamp.

GAS, OIL, AND ACETYLENE LIGHTING.

There are not many novel articles on this subject to be recorded. The discussion as to the Westminster street-lighting contract still continues in the gas and electrical journals, and a lengthy editorial in *The Electrician* (September 23) analyzes the data concerning the maintenance of lamps in some detail. An editorial in *The Journal of Gas Lighting* (August 30) reviews the progress of the INVERTED BURNER FOR PUBLIC LIGHTING, and mention is made of recent streets in London where the use of clusters of such burners is said to be proving very satisfactory.

There are also, as usual, a number of articles dealing with DISTANCE GAS LIGHTING. *The Gas World* reproduces an article dealing with Grix's method of using self-igniting pellets; these are withdrawn from the flame as soon as it is kindled. In recent numbers of the *Journal für Gasbeleuchtung* the discussion on the economies derived from automatic "pressure-wave" control are continued, several engineers taking different views on this subject. There are also several articles in the American journals in which GAS ARCS are dealt with. Special reference may be made to an illustrated article in the most recent number of *Light*, in which views are given of a billiard room, railway station, and other premises illuminated by this means. In some cases, however, it would appear that some more perfect method of shading the mantles would be beneficial.

As regards Acetylene lighting reference may be made to the description of the

Schimek inverted incandescent burner (*Acetylene*, August), for which a specific consumption of 0·2 litres per candle-power-hour (equivalent to about 140 candle-power per cubic foot of gas) are claimed, but the article does not state whether this refers to mean spherical candle-power.

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An Original Acetylene Burner (*Acetylene*, August).
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CONTRACTIONS USED.

G. W.—*Gas World.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

Some Publications Received.

The Journal of the Franklin Institute.—This number (September, 1910) contains a paper on 'Reflecting Powers of Various Metals,' by Dr. Coblentz, giving a large number of tables and curves embodying the results of his experiments on the metals used in incandescent lamps.

Dr. E. P. Hyde, *The Physical Production of Light.*—Reprinted from the *Journal of the Franklin Institute,* June and July, 1910.

Dr. B. Monasch, *Indirekte Beleuchtung mit hochkerzigen Wolframlampen,* a reprint of a paper from the *Elektrotechnische Zeitschrift,* dealing with comparative tests of various systems of indirect lighting.

W. McDougall, various papers dealing with *Visual Sensation and the Duration of the Stimulus, &c.*

Proceedings of the American Institute of Electrical Engineers.—This number contains an interesting paper on 'Tungsten Lamps,' by G. S. Merrill.

Guide Pratique de l'Usager d'Acetylene. Office Central de l'Acetylene (104, Boulevard de Clichy, Paris).—A compact little illustrated guide, dealing with acetylene in all its aspects, installations for lighting or heating, maintenance, safety precautions, &c.

The Transactions of the Institution of Civil Engineers, The Proceedings of the Iron and Steel Institute, The Transactions of the South African Institute of Electrical Engineers, The Journal of the Royal Society of Arts, The Proceedings of the Tokyo Mathematico-Physical Society, Atti della Associazione Elettrotecnica Italiana.

Lectures on the Design of Electric Machinery.

A COURSE of lectures dealing with the design of alternating current and D.C. machines is to be delivered by Mr. H. M. Hobart, B.Sc., M.Inst.C.E., M.Inst.E.E., at University College on Mondays at 5 P.M., commencing Monday, October 10th, 1910. The fee for each of the two parts of the course will be one guinea. Applications for admission should be made to W. W. Seton, University College, Gower Street, London, W.C.

The ILLUMINATING ENGINEER

·ELECTRICITY· ·ACETYLENE· ·OIL· ·GAS·

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EDITORIAL.

Recent Progress in Gas Lighting.

As announced on p. 671, the first meeting of the Illuminating Engineering Society for the next Session is to be held on November 8th, when Mr. F. W. Goodenough will read a paper on 'The Present Status of, and Recent Advances in Gas Lighting.'

Mr. Goodenough is well known to our readers as an authority on gas lighting, and there is no need for us to say anything by way of introduction on this occasion. The development of gas lighting is so rapid that there are few indeed who can keep pace with its progress, and a general paper on the subject is occasionally of great benefit to many who would otherwise have no opportunity of keeping in touch with what is being done. Members of the Society may, therefore, look forward to a most interesting evening.

There is one aspect of the matter, however, which seems to us to call for comment. The main object of this paper, as suggested above, is to provide a summary of progress and not an opportunity for controversial discussion. From the commencement of the Illuminating Engineering Society it has been made clear that it was to be conducted on strictly impartial lines. What is suggested, therefore, is that one evening should be given up to a discussion of Gas Lighting, and a second evening to a corresponding paper on Electric Lighting which, as already announced, will be dealt with by Prof. E. W. Marchant. It is also hoped that future dates will be allotted to discussions of other systems of illumination. In this way members will have an opportunity of hearing and judging for themselves the progress in all directions. We think, however, that it should be clearly understood that papers have been arranged with a view to affording information and not in order to foster unprofitable controversy regarding the

relative merits of the respective illuminants. No doubt in the future, when a sufficient number of experts, equally interested in all systems of lighting, are available to join in the discussion, an analysis of the merits of the respective systems might yield useful information. But at the present time there are few who can speak with authority regarding both systems, and the time seems hardly ripe to attempt critical discussion on these lines. We consider, therefore, that it is preferable for the Illuminating Engineering Society to confine itself for the present to providing opportunities for the very latest developments of the different illluminants to be described, and subsequently to proceed to the applications of the systems.

We understand that the Illuminating Engineering Society will devote attention to such subjects as School, Library, Shop Lighting, &c., shortly; no doubt the fact of the most recent progress in the various illuminants having already been dealt with in previous papers will then be found very beneficial.

While referring to progress in gas lighting, we should like to say a word or two regarding the visit of the German Institution of Gas Engineers, which is dealt with elsewhere in this number. All those who participated in the visits and excursions arranged on this occasion were impressed by the excellent organization displayed, and the pains taken by the various gas companies to render the visit of our German friends agreeable. We feel sure that they have carried away recollections of many interesting things seen and friendly things said, and that this interchange of courtesies will do much to promote a good understanding between engineers in both countries.

Our impressions in this respect are confirmed by a recent editorial in the *Journal für Gasbeleuchtung und Wasserversorgung*, the official organ of the German Institution of Gas Engineers, in which appreciation of the attention shown during this visit is expressed, and a graceful tribute is paid to the vast development of the gas industry in this country.

The Measurement of Surface Brightness.

The paper by Messrs. J. S. Dow and V. H. Mackinney, dealing with the measurement of surface brightness by means of a new form of portable instrument, will be found on p. 655, and contains a number of interesting suggestions.

The authors suggest that much could often be learned regarding the conditions of lighting in interiors by studying the actual "surface-brightness" of the objects illuminated. In some cases it may also be more convenient to specify that an object should possess a certain brightness, in preference to providing a certain intensity of illumination, which takes no account of the fact that a considerable amount of light may be absorbed by the surface illuminated. As an illustration of the use of the instrument in this way the authors describe some experiences in studying the brightness of wall-papers, blackboards in schools, illuminated signs, clocks and notices in railways, &c., and point out the remarkable variation in the illumination provided in different railway-carriages, &c.

No doubt there is room for confirmation as to the interpretation of the results secured by this means, but the investigations carried out by the authors seem to have been thorough, and we do not doubt but that they will be borne out by subsequent experience. We also think that the authors have done wisely in disclaiming any desire to suggest that this system of measurement involves the displacement of others. On the contrary it must be recognized that measurements of candlepower and illumination are also desirable, and that the study of surface-brightness

is merely an *additional* weapon in the hands of the illuminating engineer; the "Lumeter" instrument is devised with a view to the measurement of either quantity.

The apparatus itself is portable and compact, and it is stated that an accuracy ample for practical requirements can be secured. In this respect it is in accordance with the modern tendency in the design of illumination photometers, for it is recognized that what is now demanded for practical purposes is something simple and portable, no very extravagant degree of accuracy being required.

There is, however, one other point in connexion with instruments of this kind, which it is well to emphasize. It is extremely desirable that they should be under careful supervision in order that no inaccuracy in the proportions or arrangements may creep in; slight deviations in this respect sometimes lead to considerable errors. It is therefore satisfactory to observe that the authors propose to examine each instrument personally before it is sent out in order to ensure that everything is strictly correct; there is no doubt that a guarantee of examination of this kind adds very greatly to the value of the apparatus.

It is also suggested that the instrument can be conveniently utilized for many simple experiments in the laboratory, and that it will be found of service in many cases in which the space required by a permanent photometrical bench cannot readily be spared.

The Proposed Opto-Technical Institute.

On Monday, October 17th, a meeting of those connected with the Optical Industry was held in London, in order to discuss the proposal of the London County Council to found a central Optical Institute in Clerkenwell. Readers will find a reference to this matter on page 674. The considerable number of well-known representatives of the Optical Industry who were present were unanimously in favour of the project. The general opinion, as voiced by Mr. Aitchison, Mr. Conrad Beck, and others, was that the Optical Industry could benefit very considerably by better facilities for technical instruction and the collection of scientific data on optics.

It is now proposed to erect a central Institute to develop the work on technical optics originated at the Northampton Institute, but on a larger scale. This furnishes an instance of the great development of opinion in this country during recent years in favour of scientific methods. It is recognized that the rule of thumb methods of the past no longer suffice, and the nation which has the resources of science behind it will make the greatest progress in practical application and commercial manufacture. One matter which has no doubt also been influential in leading the London County Council to make this offer has been their determination to supervize the conditions of eyesight of school children under their charge—a decision which carries with it the necessity for providing glasses in large numbers, and also studying the conditions of illumination in schools which are responsible for defects of eyesight.

Several speakers also referred to the conception of optics as a wide branch of science, including all practical applications of light, and drew attention to the very considerable range of scientific knowledge demanded by the manufacture of optical instruments.

It was very gratifying to note that several of those present laid stress on the need for special facilities for study in connexion with such problems as the effect of light and colour on sight, and the design of photometrical apparatus, &c., all of which are matters which ought to be included in a broad definition of optics. One cannot go far in connexion with lighting problems without being struck by the part played by the eye and

the need for a knowledge of physiological optics. Yet knowledge of this kind has hitherto been in the hands of a few specialists and has not been presented in a form readily accessible to the illuminating engineer. Again the construction of photometrical apparatus frequently calls for a considerable knowledge of the details of optical design.

We hope, therefore, that the movement for the new Institute will be successful, and that those concerned in framing its course of instruction will bear in mind the particular branch of optics with which we are concerned, namely, the study of the effects of light on the eye and the design of apparatus for the testing and measurement of illumination.

Co-operation between the Central Station and the Lamp Maker.

In our last two numbers we reproduced a very important paper by Mr. S. E. Doane dealing with the effect of the Metallic Filament Lamp on the Central Station. Much has been written on this subject and conflicting conclusions have not infrequently been drawn, largely, we believe, because the problem has not been surveyed with a sufficiently wide outlook.

It must of course be recognized that the results of the introduction of metallic filament lamps must vary in different localities, and a study of Mr. Doane's paper suggests that some of the views held regarding the effect of the metallic lamps on the consumer's lighting and the central station will require modification.

In this connexion one cannot help being struck by the certain favourable conditions which seem to exist in the United States. In that country the lamp makers and the supply companies work together and agree on a common line of policy. They are able, for example, to induce the consumer to regard the new lamps not so much as a means of saving expense as a means of securing better illumination; this naturally leads to an improvement in the standard of lighting and, at the same time, interferes much less with the revenue of the supply company. By this compromise both parties, the lamp maker and the central station are satisfied, and the consumer has also no ground for complaint. As an illustration of a tendency in the same direction in this country, it may be pointed out that lamp makers now supply high voltage lamps of larger candle-power at a slightly cheaper rate, although the cost of manufacture is believed to be greater. This may be regarded as a concession to the needs of the supply companies who desire to encourage the introduction of units, which besides being more efficient, are also of higher candle-power than those hitherto employed.

One more illustration of the value of co-operation on the lines suggested is afforded by the standardization of lamp sockets and bulbs in the United States. When many lamps of differing pattern are available and the details of design may vary considerably, it is naturally very difficult to foretell what will be the effect of a certain diffusing globe or reflector in practice. Now in the United States there is no difficulty in this respect. The size of the bulb in general use is fixed, the manufacture of the lamp is standardized, and it has become increasingly common for the lamp and shades to be supplied together as a single unit. In view of the admitted inconvenience of the high intrinsic brilliancy of metallic filament lamps, one cannot but be impressed by the desirability of an understanding on this point. The matter is one of considerable moment to manufacturers of shades and reflectors who are interested in the scientific screening of sources and distribution of light, and they should lose no opportunity of helping to bring about a better understanding between the central station and the lamp-maker in the future.

Leon Gaster.

Review of Contents of this Issue.

Mr. A. P. Trotter (p. 647) discusses the extent of the errors that may be introduced into photometric measurements through Stray Light, and shows how this can be avoided by the use of suitable screens, &c. Subsequently he deals with The Precision Possible in Photometric Measurements, and quotes the results obtained by a number of observers on this point.

An important paper by **Mr. A. J. Sweet** (p. 649) deals with the Principles underlying Street Lighting. It is pointed out that the two essential points in good street lighting are *firstly* to avoid glare, and *secondly* to aim at a reasonable degree of uniformity of illumination. Of course it is admitted that different varieties of streets require a different amount of light, and that extra illumination may be necessary at important crossings, &c. But in general one has to aim at the provision of a certain uniform standard. Mr. Sweet therefore considers how these two essential requirements can both be met. In the present section of the paper he is mainly concerned with the consideration of the practical means by which the correct distribution of light can be secured, and the relation that ought to exist between height of lamp and distance apart of posts. He discusses a number of possible forms of distribution curves, and finally selects one which he considers both desirable and feasible in practice. In the present portion of the paper the author has studied the best methods of securing good distribution of illumination. In the next instalment some researches on the avoidance of glare will be dealt with.

An article by **Dr. W. W. Coblentz** (p. 663) discusses the nature of the Radiation from the Acetylene Flame. The author points out that somewhat different results are obtained by the spectro-photometric and radiometric methods, a band of selective emission apparently being found to exist in the one case and not in the other.

Following will be found a summary of a paper by **Mr. J. S. Dow** and **Mr. V. H. Mackinney** on Surface Brightness and a New Instrument for its measurement. The authors describe a new and very portable and compact instrument for measuring the brightness of any surface or the illumination in any plane. An account is also given of researches in schoolrooms, railways, dwelling-rooms, &c. The instrument can be very easily applied to determine the vertical illumination on a bookshelf or to study the distribution of illumination over a placard or wall paper. It can also be used to determine the reflecting power of materials, and for certain experiments in the laboratory where a very high degree of accuracy is not so essential as simplicity and convenience in working. The authors lay special stress on the need for supervision in connexion with the issue of instruments of this class; otherwise small defects or variation in design might creep in which would have a material influence on the accuracy and reliability of the apparatus.

An article on p. 667 deals with the Advantages of Low Pressure for electric metallic filament lamps. When a low pressure supply is available a higher efficiency can often be attained and the lamps are stated to last longer. When alternating current is available, therefore, transformers are often used in order to gain the advantage of a low voltage; small transformers are sometimes built into the lamp holder. Another system consists in the use of a large number of small glow-lamps connected in series parallel, so that if one lamp gives way the current taken by the remainder is lightly increased and the total amount of light is not sensibly altered. A short note following this article deals with The Moore

Light, and an illustration is given of the application of the system to a chapel.

Dr. B. Monasch (p. 670) contributes a brief summary of the results secured in a series of tests recently carried out on various systems of Indirect and Semi-indirect Illumination by arc-lamps and tungsten incandescent lamps. It is worthy of remark that the results of these tests are expressed in terms of "watts per lux per square metre of surface illuminated," as recently recommended by the Verband Deutscher Elektrotechniker.

On p. 671 commences a special section of the journal devoted to the Proceedings of Various Societies, &c.

Notice is given of the **next meeting** of **The Illuminating Engineering Society** in London and a series of queries is presented, dealing with gas lighting, on which, it is suggested, further information would be desirable. Reference is also made to the series of papers to be read shortly at the Fourth Annual Convention of the Illuminating Engineering Society in the United States, and to the Special Course of Lectures on illumination at the Johns Hopkins University which will be a feature on that occasion. A brief account is also given of the proceedings during the recent Visit of the German Institution of Gas Engineers to this country.

A very important announcement also came before a recent meeting of members of the optical industry, namely the offer of the London County Council to erect a special Central Optical Institute at a cost of £30,000; the hope is expressed that the questions of photometric measurement and the effects of light on the eye will receive attention when this institute comes into being.

Some particulars are also given of the recent work of the International Electrotechnical Commission (p.675).

Among other articles reference may be made to an Interview with **Prof. Dr. W. Wedding** (p. 683), in which some views are set forth as to the future scope of gas and electric lighting, &c. Reference is made to the enormous development of high-pressure gas lighting, and to the special conveniences which are advantageous to electric lighting for interior illumination. In conclusion a rough table of the costs of various illuminants is made out. Prof. Wedding, however, expressly states that the question of cost is only one of many factors affecting the choice of one or another illuminant, and he lays special stress on the Hygienic Aspects of Lighting which are now being brought prominently forward. In future, our own must be to aim at the best possible distribution and to devise improved methods of using light rather than the production of sources of higher concentrated brilliancy. Sources have now reached the limit of desirable intrinsic brilliancy.

Another note deals with Design of a Lamp-post which recently secured a prize awarded by the Royal Academy. Seeing that the design of many lamp-posts is admittedly defective from the artistic standpoint, it is suggested that the useful precedent set on this occasion might be followed in connexion with other branches of lighting fixture design.

The Illumination of a Barber's Shop is dealt with on p. 682. The illustration shows the elaborate system of inverted lighting in the sumptuously furnished barber's shop of a Chicago Hotel.

On p. 679 will be found a variety of Short Notes on Illuminating Engineering, and there are also other small items of interest distributed through the magazine. For example, on p. 662 will be found a reference to the researches of **Dr. W. Macdougall** concerning the period of time which must elapse in order that a faint flash of light may be perceptible to the eye. This has a bearing upon the visibility of flashing lights at sea. Another note (p. 666) refers to the method of Squirting Tungsten Filaments and the difficulties involved in the preparation of dies for the process.

On p. 688 and 689 will be found some Reviews of Books and Trade Notes, and the journal is completed by the usual Review of the Technical Press (p. 693).

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Illumination, its Distribution and Measurement.

By A. P. Trotter.

Electrical Adviser to the Board of Trade.

(*Continued from p. 595, Vol. III.*)

Errors (*continued*).

Stray light.—In describing the earliest known photometer, Bouguer speaks of the screen* between the two lights as an essential part of the instrument. Reference has been made to the use of screens,† and nothing more need be added here except the warning that stray reflected light is a most troublesome source of error. As in photography, stray light finds its way from unexpected directions; but there, if it is strong enough to fog the plate, it leaves evidence of its existence. In photometry, on the other hand, stray light if not detected will cause unknown errors. It is possible sometimes to correct for stray light. In making the check reading of an illumination photometer before going out for an evening's work, or on coming back, it is sometimes troublesome to enclose the standard lamp so that the room is in darkness. The diffused light need not cause serious error. A measurement should be made at the measured distance with the standard lamp and the diffused light, and a piece of black card should be held so that its shadow is cast on the screen of the photometer. A reading may then be taken of the diffused light alone. The shadow should not be larger than is necessary, or some of the diffused light will be blocked out.

* *Illum. Eng.*, vol. i.. p. 800.

† *Illum. Eng.*, vol. ii. p. 513.

With a Rumford or a Harcourt (Gas Referees') photometer stray light need not cause any error if it falls on both sides equally, but it may impair accuracy by diminishing the contrast. Or if it strikes the observer's eyes through want of proper screening it will give rise to personal error. It is difficult in some cases to distinguish between personal and instrumental errors.

Errors due to unsymmetrical construction may be avoided by the adoption of the method of substitution or double weighing.* If this is not employed the photometer head should be reversed, and the necessary constant correction must be applied to each reading, or to the mean of a set, or double measurement must be made and the means of the pairs taken.

Precision.—Finally, the magnitude of errors may be examined. Dr. E. P. Hyde† in his investigations on the Talbot disc made observations with such care and skill that "the average deviation of the readings for any one angle was in no case as large as 0·2 per cent, the probable errors of the measurements are in all cases under 0·1 per cent." Mr. C. C. Paterson, at the National Physical Laboratory, writes‡: "It is usual in giving photometric

* *Illum. Eng.*, vol. ii. p. 295

† *Bulletin of the Bureau of Standards*, Washington, vol. ii., No. 1, p. 27.

‡ *Proc. Phy. Soc.*, London, vol. xxi., and *Phil. Mag.*, August, 1909, p. 267.

results to write down the fourth figure, but even in the *most favourable* circumstances this must be written small, and the value considered liable to an error of + or — 0·1 per cent." Such precision is valuable in investigations of physical laws, or of important standards, but it would be a waste of time to attempt anything of the kind in industrial or engineering work. Kennelly and Whiting obtained from 1·5 per cent with a Bunsen to 0·5 per cent with a Lummer-Brodhun contrast pattern for lights of similar colour, and from 1·4 per cent to 1·9 per cent for lights of slightly different colour.

In an interesting paper by J. Mark Barr and E. S. Phillips* the results of a large number of photometric tests made at the Central Technical College, London, were investigated, and the errors of different kinds of photometers were calculated. These are represented in a diagram in the paper, but may be more conveniently given in figures :

Small star Leeson disc		0·35 per cent.
Paraffin block Joly photometer ...		0·4 "
Large star Leeson disc at	400 cms.	0·41 "
" " "	192·5 cms.	0·52 "
Glass block Joly " ...	400 cms.	0·49 "
" " ...	192·5 cms.	0·58 "
Bunsen grease spot ...	400 cms.	0·98 "
" " ...	192·5 cms.	0·85 "

It will be noticed that with the large Leeson disc and with the Joly block rather greater accuracy was secured by standing at a greater distance from the photometer, but this is reversed in the case of the Bunsen.

In lamp factories 2½ or 3 per cent is an ordinary limit for lamp sorting. In street work with an illumination photometer if a number of repeated readings fall within a range of 5 or 6 per cent, or, in other words, do not vary more than 2½ to 3 per cent from the mean, the work may be considered satisfactory.

But while it is easy thus to make a general statement of what appears to be a commonsense limit of accuracy for industrial work, a serious difficulty presents itself when the question arises whether a batch of lamps is up to a specification. It would be absurd to ask that they should all be exactly 16 candle-power, so a margin is allowed, say, 2½ per cent, that is, from 15·6 to 16·4. But if a lamp turns out to be 15·55 we are faced with a difference of 0·32 per cent. The allowance of 2½ per cent does not help, and a further allowance is of no use. A difference of 0·32 per cent can only be guaranteed by an experienced man with good instruments, a thoroughly good standard, and by taking the mean of a number of measurements. It is in fact beyond the range of ordinary commercial measurement, but the example shows how difficult it is to say what should be the limit of that range.

* 'The Brightness of Light: its Nature and Measurement,' read at a Students' Meeting of the Inst.E.E., Dec., 1895, not printed in the *Journal* but abstracted in *The Electrician*, Vol. 32, p. 524.

(*To be continued.*)

Amount of Illumination Required for Various Purposes.

In a recent paper on 'Illumination from the Ophthalmic point of View,' abstracted in *La Revue Électrique*, Prof. Gariel gave some values of illumination in a number of different places in Paris, determined by M. de Nerville as far back as 1890.

At the opera house, in the orchestra and the pit, the illumination varied from 10 to 13 lux ; in the hall and on the stage, it reached, on special ball nights, as much as 30 lux. The illumination in the operating rooms of the Central Telegraph Office was found to be between 15 and 20 lux, according to position. In a room measuring approximately 13 ft. by 9 ft. 6 in., painted a light buff colour and lighted by two windows, the daylight illumination at one yard from the window when the sun was not shining into the room, varied from 110 to 200 lux ; on a wet day it was reduced to 40 lux ; and, on the other hand, the illumination on one occasion when the sun was shining on white curtains, actually reached 1,100 lux.

An Analysis of Illumination Requirements in Street Lighting.

By Arthur J. Sweet.

(Paper read before the Franklin Institute, Philadelphia, U.S.A., March 3rd, 1910; slightly abbreviated.)

It is profitable to preface a study of street lighting by a glance at the historical development of this subject. The history of street lighting shows four quite clearly defined epochs, the last of which we are just entering. First there was the epoch, stretching back into prehistoric times, when the moon was the only source of street illumination in the primitive settlements of man. Then comes the long epoch, from early Grecian days down to about the beginning of the eighteenth century, when the moon was supplemented by a torch or lantern carried by those who found occasion to use the streets by night.

We are standing to-day in the dawn of a new epoch—the epoch of street illumination as contrasted with street lighting. Just as the perfection of the elevator made the skyscraper possible and brought about a new epoch in the architecture of our city business sections so the high efficiency and the satisfactory operating characteristics of our most modern street illuminants makes possible a real illumination of our streets, instead of the splashes of light with which we have had perforce to be content in the past. Just as the growing congestion of our cities demanded the tall building, so the growing and already extensive use of our streets by night demands adequate street illumination. It becomes, therefore, at the present moment a matter of peculiar interest and importance to determine the illumination requirements which must be met in order to obtain adequate street illumination.

The Two Conditions of Good Street Lighting.

There are two results to be achieved in adequate street illumination which are both of such paramount importance that it is properly a matter for individual opinion as to which should be ranked first. These are the avoidance of glare effect and the obtaining of an approximately uniform degree of illumination at all points along the course of the street, with higher intensities at street corners. These two results can only be obtained, the one by the correct solution of the allied problems of intrinsic brilliancy, total light flux, and shadow contrasts, the other by the correct solution of the problem of distribution.

Avoidance of Glare.

Glare results whenever, throughout any infinitesimal period of time, an amount of light continues to fall upon the actively visualizing portion of the retina of the eye sufficient in quantity to cause chemical changes more rapidly than the regenerative functions of the eye can keep pace with. Thus when an eye, which has been exposed for some time to conditions of dark with resultant pupillary expansion, is suddenly exposed to even a moderate light, glare effect results. An excessive amount of light reaches the retina through the expanded pupil, and the regenerative functions cannot keep pace with the chemical changes induced. Rapidly, however, the pupil contracts, the regenerative functions regain their normal control, and the glare effect passes away. If now the eye be exposed to a still greater intensity of light, beyond the very limited capacity of pupillary contraction to compensate for, or if an even moderately bright light source is introduced near the centre of the field of vision, glare effect is again experienced ; and this glare effect, after a brief period, reaches a certain state of equilibrium characterized by a quite definite decrease in efficiency of vision, which decrease thereafter increases in magnitude only

rather slowly. We may, therefore, for convenience designate a glare condition as casual, when it results from the inability of the pupil to adjust itself instantly to a changed condition of light intensity, and as fundamental when it results from a light intensity exceeding the contractive power of the pupil to compensate for, or when it results from a light source near the centre of the field of vision.

The presence of strong shadow contrasts tends to produce a casual condition of glare. The evil effect of the shadow contrast lies in the demand it introduces for instantaneous pupillary changes of considerable magnitude when the eye is turned from the shaded to the unshaded area, or vice versa. In street lighting, this casual condition of glare is much less objectionable to the slowly moving pedestrian than to the more rapidly moving automobilist or carriage driver. It is usually sufficient, therefore, to throw the shadows toward the sidewalk and to provide against too deep shadows. The avoidance of objectionably-located shadow contrasts can only be taken care of by the proper placement of the light sources, while the intensity of the shadow contrast can be decreased by using smaller light sources placed nearer together. The problem of shadow contrasts, while of considerable importance, is one that must be solved individually for each individual case. It needs no further independent consideration in this general study of our subject.

Brilliant, high candle-power light sources in the field of vision, the usual practice in contemporary street lighting, produce a fundamental condition of glare, with resultant heavy decrease in efficiency of vision—with probably also, be it noted, a permanently injurious effect on the faculty of vision. This fundamental condition of glare arises from the intrinsic brilliancy and total light flux of the light units employed and can only be avoided by the proper limitation of these. The study of the relations existing between intrinsic brilliancy and total light flux on the one hand, and glare effect on the other, becomes, therefore, one of the two chief purposes of an analysis of the illumination requirements of street lighting. The end sought should be the elimination of glare effect, or at least its reduction to such a permissible minimum as will not seriously decrease efficiency of vision nor be sufficient to produce eye discomfort.

Correct Distribution of Illumination.

The derivation of the polar curves of light distribution which will give the proper relative intensity of illumination for points along the course of the street is, as has already been noted, the second of the two chief purposes of an analysis of illumination requirements in street lighting. Here the end sought is the uniform illumination of all points along the course of the street. There is no reason either in scientific fact or in common-sense why one point along the course of the street should be more brightly lighted than another, with the exception of street intersections and similar crossings later to be noted. The present almost universal condition of brighter illumination under and near the light unit is simply a concession to our present ignorance of how to obtain something better. There is, on the other hand, abundant reason to condemn this spot-lighting practice.

At street intersections and similar crossings a brighter illumination is needed, for obvious reasons. This should be of from four to eight times the intensity of the illumination along the main course of the street. Such brighter illumination is properly provided for by employing from four to eight line units, each having the same light distribution as the units used along the course of the street, or by one or two light units of similar light distribution and larger size. The street intersection, therefore, presents no complication to our problem, and its proper treatment becomes merely a matter for adequate consideration at the time of installation.

Moderate Uniformity of Illumination Desirable.

The statement is often heard that in street lighting absolute uniformity of illumination is not required nor of

any particular importance. Taken in a very strict sense, this statement contains much of truth. But this statement has been so very generally used as a refuge for loose thinking, by the scientific man as well as the layman, that it is worth a moment's careful consideration. It is true that a variation of two to one, taking the minimum intensity as unity, is only barely noticeable and is entirely permissible. But let us invariably ask our friend, who says uniformity is not required, what numerical value he will assign as ratio of maximum to minimum intensity. If he gives us four to one, or a less ratio, we will agree with him and ask him to oblige us by keeping this ratio in mind in our further discussion. If he gives us eight to one or twenty to one or some such figure, we will disagree with him; and we will propose a hopeless task to him if we ask him to justify, by properly established scientific fact, such a ratio as permissible from any other standpoint than that of our possible inability to obtain a greater uniformity. At the same time we may profitably point out to him that the ratio in present practice most frequently falls between one hundred to one and five hundred to one.

Measurement of Illumination; Horizontal or Vertical?

Another much-mooted question concerns the way in which illumination should be measured, whether horizontally or perpendicular to the light ray. The latter method has been largely adopted in American practice chiefly through the influence of the commercial interests concerned, who desire to make the minimum value look as large as possible. There is little to be said in favour of it except that it may help us to remain in a fool's Paradise concerning the satisfactoriness of the illumination we are getting. It is true that in street service, illumination is desired at different times on almost every conceivable plane. But the best single measure of how well these many diverse requirements are met is the intensity of illumination on the horizontal plane. The horizontal plane, therefore, which is the accepted reference plane in interior lighting, is the logical and most satisfactory basis for street illumination measurements.

Methods of Spacing Units.

The ideal to be aimed at, therefore, in street lighting, as far as intensity is concerned, is uniform horizontal illumination. On this basis we can now proceed to derive the ideal curves of light distribution. These curves once derived, we may properly take into account the fact that absolute uniformity is not of importance: and we will only ask that the actual light distribution sought for as a practical ideal, show no greater variation from our theoretical ideal than four to one in ratio of maximum positive variation to maximum negative variation, as read in percentage values of the theoretical curve along the corresponding angles.

The nature of a street makes most natural a placement of light units as a line of single units extending along the street, the units being hung over the centre of the roadway or located alternately on either side. For all practical purposes, these two cases can be treated as one, the separation of adjacent units being taken as the *straight line* distance between the units, and the distribution curve derived being the correct distribution in a vertical plane passing through the unit concerned and the adjacent unit.

There are an infinite number of light distributions which will give uniform illumination from a line of light units along a line extending immediately under those units. Other considerations than the obtaining of uniformity must therefore serve to enable us to select the most desirable distribution curve.

Two such considerations are of especial importance and may therefore be applied with especial propriety. First, we should seek such a distribution as will be best suited for actual practical attainment. This consideration is of the more importance because, as we shall find, even when maximum weight is given to this consideration, our derived curve will present considerable though by no means insurmountable

difficulties of practical realization. Second, the illumination at any point should be derived from a source as near as possible in order to avoid both excessively long shadows, and the glare effect which results from the high candle-power made necessary by illumination at great distances.

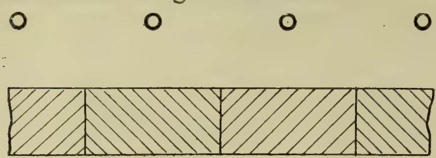


FIG. 1.

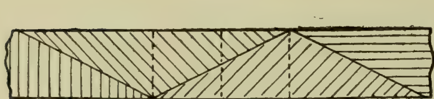


FIG. 2.
Distribution Curves of Street Illumination.
o indicates position of lamp.

Fig. 1 shows one possible illumination curve. Here each light furnishes the entire illumination on either side out to a point midway to the next light. This curve would mean a light distribution in which the candle-power values dropped instantly from a maximum to zero at the angle subtended by half the separation of the units—a condition impossible of satisfactory realization. This distribution curve is also undesirable because it shows a considerably higher maximum candle-power than would be required by certain other forms of illumination curve. Fig. 2 shows an illumination

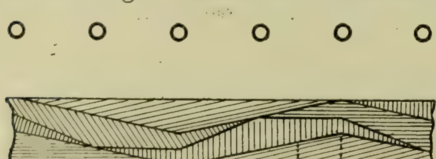


FIG. 3.
Distribution Curves of Street Illumination.
o indicates position of lamp.

curve in which the intensity values decrease uniformly from a maximum directly beneath the lamp to zero underneath the adjacent lamp. The corresponding distribution curve has its maximum at an angle subtended by the separation of the units, beyond which the candle-power values drop instantly to zero, while in addition the maximum has an unduly high value. Fig. 3 shows an illumination curve in which the intensity values decrease uniformly and reach zero under the lamp beyond the adjacent lamp. Enough has already been deduced to make it obvious that the corresponding distribution curve would be particularly undesirable. Fig. 4 shows a sine wave type of illumination curve—a more satisfactory type than any above considered. This distribution curve has a relatively low maximum, and is as well adaptable to practical realization as any curve obtainable. It has, however, one defect. The maximum value occurs at an angle considerably greater than that subtended by half the separation of the units. To obtain minimum glare

FIG. 4.

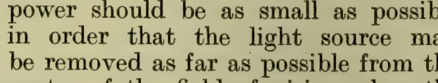


FIG. 5.
Distribution Curves of Street Illumination.
o indicates position of lamp.

effect, the angle of maximum candle-power should be as small as possible in order that the light source may be removed as far as possible from the centre of the field of vision when the eye reaches the point toward which the maximum candle-power is directed.

Many other types of illumination curves could be given and the corresponding distribution curves shown to be open to objection. Suffice it to say that it can be established by a mathematical line of reasoning, which space limitations do not permit to be here given in detail, that the curve which best meets the conditions imposed is such as shown in Fig. 5. This curve is formed by two circle quadrants combined as shown. The correspond-

ing distribution curve shows a low maximum which occurs at a slightly smaller angle than that subtended by half the separation of the units. It is also as well adaptable to practical realization as any curve obtainable.

We have, therefore, obtained the ideal illumination curve from which the desired distribution curve can be easily derived. Our next task is to put these results into such form as to be easily applicable to practical conditions.

Best Relations between Distance Apart and Height of Lamps.

The relation between any desired illumination results and the distribution required to produce those results depends, in the type of problem under consideration, upon :

a. The distance between adjacent units.

b. The height of the light unit above the street.

It is obvious that any given distribution curve will give the same proportionate illumination results so long as the relation between the separation of units and the height above street is kept constant. For, so long as this relation remains constant, the angular relations are unchanged. Let us call this relation M.

$$M = \frac{\text{distance between adjacent light units}}{\text{height of light unit above street}}$$

For any value of M there is a given distribution curve which will produce the desired illumination result.

Present-day street lighting practice shows a wide variation in the value of M. The writer has recently addressed the managements of the central stations and gas interests in most of the large cities of America and through their kind co-operation obtained an official statement in each case as to average, maximum and minimum separations, and mounting height above

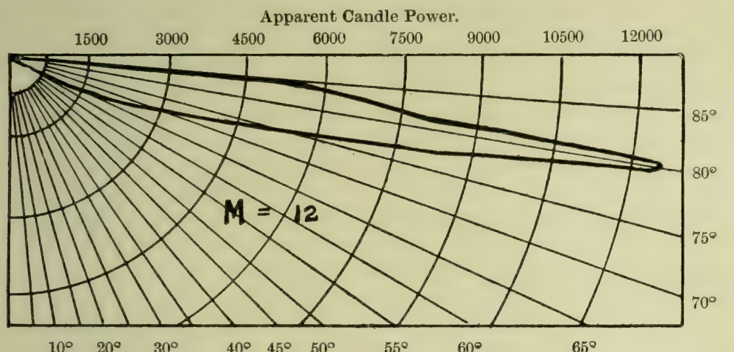


FIG. 6.—Polar Distribution Curve of a Lamp, to give Uniform Illumination when M=12.

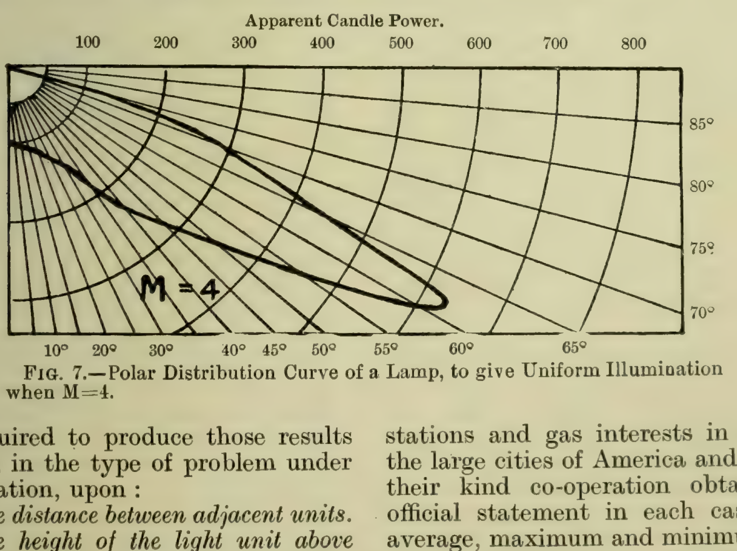


FIG. 7.—Polar Distribution Curve of a Lamp, to give Uniform Illumination when M=4.

street. The values of M thus obtained (based on average separations) vary from $M=5$ to $M=31$. The smaller cities would probably show in general a higher value for M than the large cities. All things considered a value of $M=15$ can probably be taken as the most representative value of present-day American practice, with a marked tendency towards smaller values in the more recent installations.

Fig. 6 shows the distribution curve required to produce uniform illumination when $M=12$. It needs no specialist to point out that such a curve as shown is impractical for actual realization, and would be extremely undesirable, even if it were practical to obtain it, on account of the excessive glare effect resulting from the very high candle-power maximum at a large angle. It will be observed that the maximum candle-power is about 130 times the minimum, or zero degree, candle-power.

Fig. 6 serves one excellent purpose. It shows concisely and beyond argument that, with a value $M=12$ or greater, any attempt at adequate street lighting is absurd. If ignorance and a false economy compel an installation value of $M=12$ or greater, the pretence of obtaining "street illumination" should frankly be abandoned. Instead, the lights should be installed on the basis of a system of street markers, and located where they will best serve in this way. In such a case, maximum usefulness as markers will be obtained when the candle-power values at the different angles are as close as possible to, yet not exceeding, the limits imposed by the avoidance of glare effect. Be it noted that in sparsely settled districts, where the very slight use of the streets by night may not warrant adequate street illumination, such a system of markers has a very real field of usefulness. But it should avowedly be a system of markers, not an abortive attempt at street illumination.

The curves $M=4$ (see Fig. 7) and $M=6$ would also be comparatively easy of attainment with the incandescent lamp or with the inverted gas mantle. This is of especial importance since, with these lower values of M, such smaller units give amply sufficient intensity of illumination except in those business centres where night traffic is considerable.

Smaller values for M than 4 would obviously fulfil all the conditions imposed by the requirements of good illumination. It will later be shown by our study of glare effect that a value $M=3$ is necessary to obtain best results whenever, on account of shaded conditions of street or other considerations, it is desirable to mount the units at a height of 15 ft. or less above the street. Closer spacing of units than $M=3$ entails a corresponding increase in installation and maintenance costs, and is not demanded by the illumination limitations of the problem.

Summary of Requirements of Street Lighting.

Summing up the previous paragraphs, the requirements of good street illumination, as determined by distribution considerations, are as follows: Uniform horizontal illumination is the ideal to be aimed at, and the approximation to this ideal in actual practice to within a four to one ratio of maximum to minimum may be taken as sufficiently close for all practical purposes. The most desirable type of curve for the illumination delivered by the individual unit is such as shown in Fig. 5. When the light sources are separated by a distance greater than six times the mounting height above street, it becomes impractical to design a unit giving such light distribution as would be required for a sufficiently close approximation to uniform illumination. When the light sources are separated by twelve times the mounting height or greater, the pretence of adequate street illumination becomes an absurdity; and when ignorance of the factors involved has led to such separations, best results can be attained by abandoning all pretence of street illumination and by installing the light units as a system of street markers. Separations of three to six times the mounting height are required by distribution considerations.

(To be continued.)

Surface-Brightness, and a New Instrument for its Measurement.

By J. S. Dow and V. H. Mackinney.

(Abstract of paper read before the Optical Society, London, Oct. 13th, 1910.)

It is very interesting to observe how photometry, from being regarded merely as a subject of academic interest, came to be considered in the light of an industrial process.

It was early regarded as important that the gas supplied should have a certain specified illuminating power. Subsequently it was recognized as equally important to test the source of light. But as early as 1882 Sir Wm. Preece pointed out that although measurements of the illuminating power of sources of light are very desirable, yet they do not, strictly speaking, yield us the result with which we are ultimately concerned. What we are really anxious to know, he pointed out, is not only the light of the lamp given by the lamp used but the actual intensity of illumination "on the surface of the book we are reading, or the paper on which we are writing, or of the walls on which we hang our pictures," &c.

Yet, after all, what really concerns us is not only the illumination arriving on a surface, but the actual "surface-brightness" which results. For example, it may happen that a good illumination is provided to show off the wall-papers in a room. But if these are of a very dark tint only a fraction of the light reaching them is reflected again. What is really necessary in such cases is to secure that the walls have a definite *brightness.* In the same way it may be urged that it is the surface-brightness of the page of a book, after a certain amount of light has been lost owing to absorption by the paper, that enables us to read, and it is the contrast between the brightness of adjacent objects which enables us to distinguish one from another. Naturally this does not mean that the measurement of illumination is superfluous, nor that it is not still as essential as ever to measure the candle-power of the lamps we use or the illuminating and calorific value of the gas we consume. But the measurement of surface-brightness would seem to be an important link in the chain of processes connected with the study of illumination, all of which have their sphere of usefulness.

The "Lumeter" Surface-Brightness Photometer.

It therefore occurred to the authors that a description of a new form of instrument, primarily designed for the measurement of surface-brightness (though it can also be used for other purposes) might be of interest. It is to be distinguished by the name "Lumeter."

The instrument was described in its crude form at a recent meeting of the Illuminating Engineering Society,* but since that date its principle has been studied more carefully, and a number of improvements have been introduced and difficulties overcome.

Description of the Instrument.

The general appearance of the apparatus is shown in Fig. 1.

The idea of the instrument is to enable an observer to measure the surface-brightness of any surface by comparing it direct with a standard illuminated white one. The manner in which this is done will be understood from Fig. 2. The observer looks direct at an illuminated screen and sees, through an aperture therein, the illuminated surface to be studied—for example, a picture, or some object in a

* *Illum. Eng.*, Lond., June, 1910.

shop window. This screen is illuminated by an opal glass plate. Behind this is a small metallic filament glow-lamp at a sufficient distance to render the screen of uniform brilliancy. In the illustration the screen, with its circular aperture, has been taken out and will be seen resting against the box. The sector-shaped opal surface can also be clearly noted.

The screen has been made by depositing a matt white precipitate on thin glass and then scraping away a central disc. In this way a very fine line of division between the photometric surfaces can be secured; this device, like many others utilized in the instrument, is largely due to the ingenuity of Messrs. Conrad and William Beck. The screen is subsequently covered by a thin glass plate, which is bound in position. The actual white surface is thus preserved from air and moisture, and the glass cover can be handled with safety and easily cleaned.

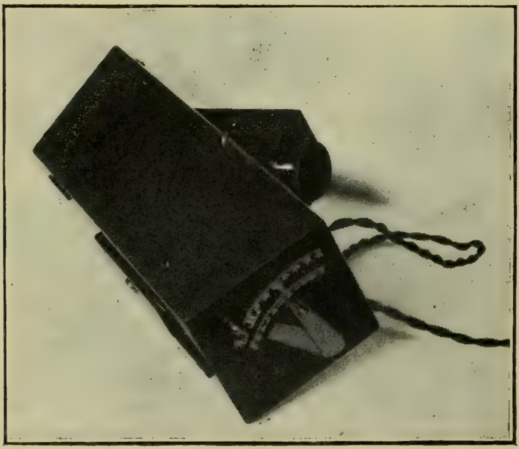


FIG. 1.—General View of Lumeter Instrument.

The method of altering the illumination is somewhat unusual. The screen S (see Fig. 3) is covered by an opaque metal screen, which only allows a sector to be exposed. In front of this evenly illuminated sector two corresponding opaque screens, attached to levers A and B, can be made to pass. As the screen A is moved in front of the sector its area, and therefore its intensity as a light-source, will be uniformly diminished from, say, 1 to 0·1. The remaining intensity, 0·1, is derived from the part of the surface still visible through the ring R. The area of R is arranged to be exactly 1-10th of the total area of the bright sector. The lever attached to A therefore travels on an equally divided circular scale with 9 divisions from 1 to 0·1.

Having drawn across the lever A, we can gradually reduce the illumination still further by also bringing over the lever B. This exactly resembles A, with the exception that there is no ring cut out. In doing so we gradually cut off the illuminated portion of the opal plate still left exposed and reduce the illumination uniformly from 0·1 to 0. The lever B travels on a second scale immediately above that of A, graduated from 0·1 to zero.

Method of Calibration.

A word or two may be said regarding the units in which the scale ought to be calibrated. Strictly speaking, the instrument measures "surface brightness" or "intrinsic brilliancy." This may be expressed either in terms of "candles per square centimetre" or in terms of the illumination in lux or foot-candles which a truly white surface would have to receive in order to have an equivalent brightness. The latter is the method most suitable for most practical purposes, and has been adopted in this instrument.

Before using the apparatus one adjusts the position of the glow lamp illuminating the opal plate until the brightness of the white surface S (as compared with another similar white surface illuminated by a standard lamp at a specified distance) is, say, exactly one foot-candle. One then fixes the lamp in this position and regards the scales as registering in foot-candles.

It is, of course, desirable to reset the lamp from time to time as the pressure of the accumulator gradually drops and the candle-power of the lamp eventually falls. In doing so it is naturally preferable to utilize an incandescent lamp or flame-standard

mounted on a photometric bench, but probably an accuracy sufficient for many practical purposes can be attained by the use of a "standard candle" placed exactly one foot away. When using such a candle (which should be obtained from a recognized source), draughts must be avoided, and it must be allowed to burn for about ten minutes or so until an even cup of molten wax is formed. The wick should also assume its normal state, being neither too stiffly upright nor sagging over horizontally so as to cause the flame to flare up. With a little care in these respects an accuracy within 10 per cent can probably be obtained.

It is also possible to check the instrument roughly by noting the illumination under some familiar conditions. For example, one of the authors has studied the illumination on the table in his library, and during the last two months the reading, as

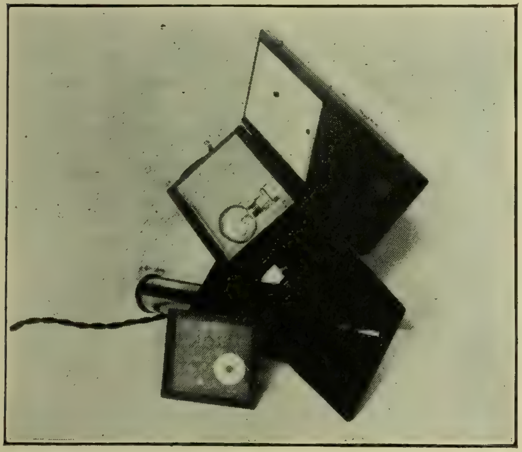


FIG. 2.—Details of Instrument.

noted with this instrument, was never more than 2·0 foot-candles or less than 1·75—a difference which might easily have been caused by a fluctuation in the supply voltage. Now for many practical purposes an observer would be satisfied with the knowledge that the instrument has not varied by more than the above percentage.

It should be noted, however, that in many cases we are only concerned with *relative* values when using such an instrument. For example, it may be desired to demonstrate that the illumination on a table is multiplied to a certain amount by using a certain reflector; or it may be desired only

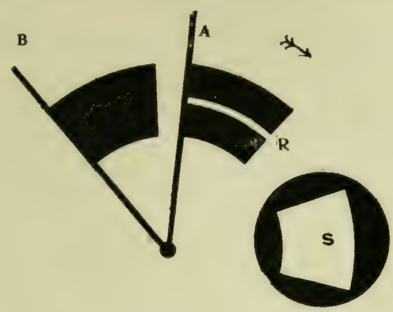


FIG. 3.—Diagram of Sector-aperture.

to study the distribution of illumination over a table, wall, or illuminated placard, &c. In such cases the extreme accuracy of the absolute value of the result does not greatly matter; all that is desired is that the instrument shall not vary during the measurement and that the scale shall be strictly proportional.

Range of the Instrument.

By means of the device already described one can measure values from under 1-100th to one foot-candle. It is also proposed to equip the instrument with two dark glasses, each absorbing 1-10th of the light passing through them, in order to increase the range of the instrument upwards. Either one or both of these glasses can be inserted in the path of the rays from the surface studied, thus enabling values as high as 100 foot-candles to be measured. Naturally some care is necessary in selecting glasses which do not unduly absorb light of certain colours, but there seems to be little difficulty in securing that any error so caused will not be material from a practical standpoint. As an illustration of the wide range of brightness that can be measured by this means, it may be mentioned that the writers have measured values of over 50 foot-candles in shop-windows, while it is also possible to estimate the brightness

of the sky in the night-time. This proved in one case to be about 0·008 foot-candles. In another case, owing to the diffusion of light from neighbouring arc-lamps, a value of 0·015 foot-candles was registered.

Accuracy of the Scale and Necessity for Supervision.

There were a large number of special difficulties originally met with in securing a uniform scale. It is necessary that the opal surface, which is ground on both sides, should be perfectly diffusive and uniformly illuminated all over. By gradual modifications in the original design the various scale errors were gradually eliminated, and it is now anticipated that the scale can be regarded as correct within 5 per cent over its length. This order of accuracy was obtained partly by correct proportion and relative position of the lamp, opal surface, and screen, and also by enclosing the lamp in a white diffusing chamber, on the principle of the Ulbricht globe.

The authors, however, would like to emphasize the importance of careful supervision in the case of instruments of this kind, as relatively small defects may lead to considerable errors if due care is not taken. They therefore propose to examine personally every instrument before it is sent out for use in order to ensure that everything is satisfactory. It should, of course, be understood that the obstacles referred to above were difficulties *in design only* and not in use. Once the instrument is correctly made it should give anyone using it no trouble, as the parts are not easily deranged and the whole construction is simple.

Measurement of Illumination and Candle-power.

Although mainly intended for the measurement of surface-brightness, the instrument can be easily employed to measure illumination. In this case a white surface is exposed to the illumination of the standardizing lamp, and the same surface is used for subsequent measurements. For this purpose a screen that is diffusive and dead white is desirable. Yet, as the same screen is used both in calibration and in experiment, any error caused by imperfect compliance with these conditions tends to "cancel out" as far as measurements of illumination are concerned. For practical purposes, good white cardboard or drawing paper, from which any glaze has been removed, answers. One case in which white card or paper is convenient is in getting a rough idea of the reflecting power of wall-papers, curtains, &c. All that is necessary is to pin the card on the material in question, and take, first, a reading of the illumination on the white card, and then of the surface-brightness of the adjacent material.

By a very simple addition the instrument might also be utilized to measure the candle-power of lamps in a room or street. A small tube terminating in an opal glass plate, ground on both sides, is inserted in front of the photometric screen. The observer then merely presents the instrument towards the lamp studied and balances the illumination of this opal plate. Then, knowing the distance of the source, he can readily calculate its intensity. It is, of course, necessary to determine once for all the constant of the instrument before use in this way.

PRACTICAL MEASUREMENTS OF ILLUMINATION AND SURFACE-BRIGHTNESS.

The compactness and portability of the instrument, which enables it to be fixed, together with the accumulator, in a small case and carried knapsack fashion on the back, or even in an overcoat pocket, is very convenient for practical measurements.

Moreover, a measurement of the brightness of a surface by means of this instrument is unaffected, within wide limits, by the distance away of the observer.

The chief advantage of surface-brightness measurement is that it enables one to go right to the root of the matter—to study the illumination at the exact spot with which we are concerned. With the instrument described one can determine not only the illumination provided by the lighting engineer, but the resulting actual brightness of the objects illuminated. Again, in studying distribution of illumination it is often

very convenient to measure surface-brightness. For example, one can determine the distribution of light over a large placard or the face of a building by merely pointing the instrument in the desired direction, and in this way one can reach parts of which it would otherwise be extremely difficult and in many cases almost impossible to get a measurement. As an extreme illustration of measurement at a distance, it may be mentioned that we attempted to measure the surface-brightness of the dial of the clock in Westminster Tower, which, viewed from the lower end of Whitehall, will just cover the aperture in the instrument. Owing to the fact that the surface is interlaced with opaque lattice work it was not easy to get an exact reading, but the apparent illumination seemed to be between 1 and 2 foot-candles.

At close quarters the method is also advantageous, because one can map out the illumination on quite a small area; *e.g.*, the distribution of light beneath table lamps, which, by the way, is often curiously uneven. Another feature of measurement of surface-brightness is that one can often obtain useful information by studying the brightness of inaccessible objects inside glass cases. For example, one can study the contents of shop windows without it being necessary to take the instrument inside among the goods, and it seems reasonable to suggest that the best method of judging whether a show window is well lighted or no is to study the appearance of the lighted goods themselves.

Again, the small white surface studied can be placed anywhere we like, so that it is easy to examine the illumination at any point on a tool or piece of machinery, &c.

In conclusion, a few experiences of the use of the instrument in various interiors, &c.

Dwelling Rooms, and the Study of Wall-papers.

The instrument can be easily applied to determine both the illumination and the surface-brightness of wall-papers in various rooms in a house. All that is necessary is to set up the white surface on the wall and to measure first the brightness of the white surface and then that of the adjacent wall-paper. An incidental advantage of the method is that, the eye being fixed on the aperture, the surface behind is out of focus, so that one is unconscious of the pattern of the paper studied and automatically obtains a mean result.

There seems to be a lack of data regarding the desirable surface-brightness of walls although general figures have sometimes been quoted for the illumination. One would be inclined to suggest, with reservations, that a "cheerful" room should have walls with a surface-brightness, by artificial light, of not less than 0·3 foot-candles. No doubt in many rooms with very light walls much higher figures than this would be obtained, however, while in certain other cases more "subdued" effects might be desired. Under practical conditions a very fair order of accuracy may be expected in such measurements, and it might be supposed that this simple method of studying the absorbing powers of various surfaces would commend itself to architects and decorators. At all events when an idea as to the probable absorption can be so readily formed there seems no excuse for the extreme vagueness that often prevails at present.

One can, of course, easily ascertain the intensity of illumination on tables, bookshelves, &c., by attaching thereto the little white surface on the spot where a measurement is desired. In a library mentioned above the vertical illumination on the bookshelves is rather over one foot-candle and the horizontal illumination on the table in the neighbourhood of 1·8 foot-candles.

Light Reflected by Various Qualities of Paper.

The same remarks might be made regarding qualities of paper employed. One is too often inclined to suppose that if an illumination of one foot-candle is provided all has been done that can be expected to render reading comfortable. But the paper on which the characters are printed may reflect but a fraction of the light impinging upon it. When one is reading a newspaper

in a lighted train one frequently suffers through this fact as well as through deficient illumination. The following figures were recently obtained for three well-known newspapers :—

Reflecting Power (Relative).

White Cardboard	100	
Westminster Gazette	90	(very approx.)
Globe	80	,, ,,
Sporting Times	53	,, ,,

And it may be added that the cardboard in question was not as white as might have been selected, so that the results are high, if anything. However, many of the papers in use, such as blue tramways tickets, some theatre programmes, &c., reflect very much less light than the above.

Studying Illumination in Schoolrooms, &c.

A great deal has been said recently about the necessity for good illumination in schoolrooms. The chief requirement in an instrument of this class is portability, and, provided it is reliable in action and not liable to get out of order, an excessive degree of accuracy is seldom called for. Although a knowledge of the horizontal illumination on the desks is useful, this does not always describe the exact conditions under which the child reads. He may lift the book at such an angle that he normally receives but a fraction of the horizontal desk illumination. Or it may be that, unfortunately, there are obstructions which cast a shadow on the page as usually studied, or the paper of the book may be of an inferior quality which only reflects a small quantity of light. Therefore the most exact data regarding the illumination he enjoys would be obtained by looking through a surface-brightness photometer over the child's shoulder so as to read with the apparatus exactly that brightness which his eye would receive.

When one comes to consider illuminated black diagrams and blackboards we are concerned mainly with surface-brightness. For what really enables a child at the back of the room to distinguish the writing on the board is the contrast between the blackboard and the chalk.

Until one attempts to make measurements one would hardly credit the variations in daylight that occur even in a room liberally supplied with windows. At a technical college known to the writers there is one classroom, 30 ft. by 25 ft., with high windows all the way down the left-hand side (facing the street). Yet at 5 o'clock on a September day the illumination on the best-lighted desk was 10 foot-candles, while the worst seat received only 0·6. Moreover, the illumination of the blackboard varied from 5 foot-candles at one end to only 0·5 at the other.

Illumination in Tramcars, Railway Carriages, &c.

There are few instances of wider variations in lighting conditions than those which seem to prevail in railway carriages and tramcars. As yet there does not seem to be any regular standard adhered to, although it may safely be said that the nature of the illumination is often a powerful inducement to travellers to select one route rather than another.

The illumination provided in the tubes and underground trains of London varies very greatly. In one of the tubes by which the authors habitually travel the horizontal illumination is usually just about 1·1 to 1·3 foot-candles while the train is at rest and 0·7 to 0·9 foot-candles when the train dives into the tunnel. This value has been repeated so often that one could almost check the instrument by a reading on this tube.

In other cases readings between 2 and 3 foot-candles were obtained, while in one comparatively short journey on another tube the illumination fluctuated between 0·2 and 0·8 foot-candles. Perhaps the most remarkable instance of poor illumination was a tram in which the illumination danced about between 0·1 and 0·2 foot-candles. The surface-brightness of one series of time-tables immediately opposite a lamp was 0·3 foot-candles; but another series a little further along yielded a result of only 0·07! The surface-brightness of clocks in several

tube stations was as low as 0·2 and 0·03 foot-candles respectively.

OTHER USES OF THE INSTRUMENT. As stated above, the idea of the authors in devising this instrument has been first and foremost to provide a compact and portable apparatus for the measurement of surface-brightness and illumination in any plane. Nevertheless, special care was taken in the design of this instrument in the hope that it might also be found useful for many laboratory purposes in which the very highest precision necessary for standard work was not demanded. It is somewhat curious that in photometrical laboratories, in technical colleges, &c., there is often no mean between extremely elaborate experiments and the use of inconvenient and antiquated apparatus.

An instrument such as this, in which a uniform scale is employed, saves a considerable amount of time, since the result can be read off at once; and the long calculations based on the inverse square laws, usually associated with work on a photometric bench, are avoided. Probably, therefore, an instrument based on this system, which can be used to measure either surface-brightness illumination or candle-power, would often be a valuable adjunct in the photometrical laboratory. Its portability and compactness would often be an advantage, since a photometric bench takes up a great deal of room and is not readily transferred from one part of the room to another. The instrument should therefore be serviceable for fundamental experiments by students on glowlamps, &c., as well as for illumination measurements. During an experiment the apparatus should be mounted on a short tripod. One type of experiment for which it seems particularly well suited is the study of the absorption powers of solutions and glasses, &c., and the reflecting power of different surfaces.

It might also be applied to obtaining polar curves of light distribution, since it can readily be pointed at a lamp so as to receive the light from any desired direction. Another possible method of applying the instrument for this purpose would be to fit it with an elbow tube terminating in a ground opal plate which could be rotated to any desired angle without the position of the instrument being affected.

The authors desire to express their appreciation of the care and trouble taken by Messrs. R. & J. Beck, Ltd. (68, Cornhill, London, E.C.), the makers of the instrument, and to mention their indebtedness to Messrs. Conrad and William Beck for many valuable suggestions which have been taken advantage of in the design. Acknowledgment is also due to the courtesy of the Holophane Co. in granting permission for tests of the instrument to be carried out in their laboratory.

And in conclusion the authors would like to record their grateful appreciation of the encouragement and interest in this work of Mr. L. Gaster and their consciousness of the benefit derived from the recent discussions of the Illuminating Engineering Society on the subject of 'Glare, its Causes and Effects,' and 'The Measurement of Light and Illumination,' which were largely instrumental in suggesting the value of an instrument of this kind.

Discussion.

A short discussion then ensued.

Mr. Conrad Beck referred briefly to the extreme variations that occurred in daylight illumination. The wide range of the instrument should render it specially convenient for studying these fluctuations.

Mr. L. Gaster pointed out that what was chiefly wanted for many practical purposes was not so much very extreme accuracy as convenience and simplicity. He was particularly glad to note that the authors intended to examine each instrument before it was sent out, as, in his experience, such supervision was very necessary, and perhaps especially so in the case of photometric instruments.

Mr. J. Darch referred to the tendency in modern lighting to secure a soft effect by screening the lamps and making use of diffused light from good reflecting surfaces. He thought an instrument such as this, which would enable one to obtain a ready idea of the brightness of illuminated surfaces, would be very serviceable, and he had been looking for such an instrument for years.

Mr. E. P. Hollis inquired whether it would not be better to use only the diffused light in the white chamber to illuminate the opal screen, so as to secure greater uniformity, and to screen off the direct rays from the small glow-lamp.

Mr. S. Smith remarked on the difficulty of securing neutral dark glasses and of testing this matter spectroscopically.

Mr. S. D. Chalmers, after making some general remarks on the importance of measurements of illumination, went on to suggest that it might be desirable to add some apparatus to the instrument which would enable an experimenter to tell when the accumulator required to be recharged. He also suggested that a possible method of reducing the light from surfaces studied would be to make use of a double reflection from two thin glass plates.

In reply Mr. Dow said that there would be no difficulty in adding accessory apparatus to measure the voltage of the accumulator, but this would add to the bulk and cost of the instrument, and he was inclined to think that the experience of the observer should suffice. One indication of a falling pressure was that the light from the lamp became yellower in tint. The suggestion regarding the reduction of light by reflection was one which should certainly be borne in mind.

As regards Mr. Smith's point, he thought glasses could be secured sufficiently neutral for practical purposes, but in accurate spectroscopic work he would prefer to use some other method of dimming the light.

It was convenient to use the direct light from the small lamp in the whitened chamber, as the motion of this lamp to and fro afforded a simple method of setting the instrument. Moreover, if one depended only on the light diffused in the chamber, it would be somewhat difficult to secure a sufficiently high illumination of the photometer screen.

The Time Taken by the Eye to Perceive a Flashing Light.

It seems to have been accepted in the past by engineers concerned with the design of flashing lights for lighthouses that a flash must persist for at least one-tenth of a second in order to be clearly perceived by distant observers. Dr. W. McDougall, however, in a recent paper in the *Journal of Psychology*, points out that the few experiments that have been made were not sufficiently complete. They have not taken into account either the variation of this period according to the intensity of the light, or the fact that very dim lights are always more readily perceived by the peripheral retina of the retina ; this is more sensitive to a feeble light than the fovea, the central part of which is mainly utilized at high illuminations. It is known by astronomers, for example, that a weak light can most readily be seen out of the tail of the eye. He has sought to supply this deficiency in data. His apparatus consisted of a large revolving disc having sectors cut out at its periphery. This is placed in front of a lantern so as to alternately cover and expose a spot of light. Having carried out a large number of experiments on the time required to perceive very dim lights, he finds that, for the dimmest light which is perceptible at all, a minimum of $\frac{1}{5}$ sec. is required.

It appears from this that many of the flash lights now in use might be visible at greater distances if they were exposed for a somewhat longer period.

A Note on the Selective Emission of the Acetylene Flame.

By W. W. Coblentz.

I.—Historical.

That particles of incandescent carbon in flames, and especially incandescent lamp filaments of carbon, can have a sharp band of selective emission just beyond the visible (red) spectrum has always seemed to the writer to be doubtful. The properties of "soot" and "lamp black" are a high absorptivity in the violet which decreases rapidly just beyond the red. The experiments of Ladenburg*, on the absorptivity of the incandescent particles in the acetylene flame, show a similar property of a high absorption in the visible spectrum which decreases uniformly in the infra-red. In order to have a sharp band of selective emission the flame should show a band of strong well-defined absorption in this same region. The curves of Ladenburg do not indicate such a condition. From all the experimental data now at hand one would expect a much higher emissivity in the violet, decreasing uniformly into the infra-red, just as obtains in the metals.

That this is actually the case for acetylene was found by Dr. Burgess, who kindly made the measurements with an optical pyrometer.† The pyrometer showed an emissivity equivalent to a black body at a temperature of 1357° in the red, to 1450° in the green, and to 1475° in the blue, which is the order of selective emission of metals.

Spectrophotometric intercomparisons of various flames and incandescent lamps seem to show a band of selective emission in the deep red. The logical procedure is, of course, to compare such sources against a black body which cannot emit selectively in favour of some particular spectral region. During the summer of 1908 the writer placed his services and his furnace, "black body," at the disposal of Dr. E. P. Hyde, to make a spectrophotometric examination (to ·71μ in red) of carbon lamps against the "black body"; but no selective emission could be found in the carbon lamps. Upon the writer's insistence that the only logical thing to do was to examine also the acetylene flame, Dr. Hyde* kindly consented to supply an assistant to aid in the work.

At that time no permanent acetylene apparatus was at hand, and a temporary generator and gasometer were constructed with which acetylene gas was produced for two series of spectrophotometric comparisons, and for the pyrometric (temperature) comparisons just mentioned. Because of the difficulty of operation and lack of assistance the work was discontinued until the completion of the Bureau's permanent acetylene gas generating apparatus, which now consists of an automatic generator, attachable to

* Ladenburg, *Phys. Zeit.*. Vol. VII., p. 697, 1906.

† See *Bulletin Bureau of Standards,* Vol. V., p. 364, Table 3.

* Hyde, *Journal Franklin Institute*, Vol. 170, p. 29, 1910. A correction with reference to the statements on p. 26 is also desirable. The black bodies used were *not* constructed in the same way (see *The Illuminating Engineer*, London, 3, p. 451, 1910), which speaks well for the agreement in the measurements. The quoted temperature difference amounting to 8° is erroneous, and attention was called to this fact at the time the work was done. A subsequent examination of black body No. 2 by means of a newly calibrated thermocouple and also with an optical pyrometer showed that the maximum allowable difference between the thermocouple scale and the optical temperature scale was 5° and it may have been as small as 3°. On the whole, it is felt that the temperature measurements of the two black bodies could not differ by more than 3° to 5° or one part in 400 to 600, which is more precise than any one will be willing to guarantee *absolute* temperature measurements at 1400° to 1500° C. Now, any one at all familiar with the measurement of the temperature of the radiating wall of a "black body" furnace at excessive temperatures, as was done in this case, without recalibrating the thermocouples immediately thereafter will appreciate that the precision we attained was very satisfactory. The discrepancy of 8° is to be sought for elsewhere than in the temperature measurements, and may just as legitimately be ascribed to changes in the comparison lamp, of which but one was used in making the colour match settings.

either a high- or a low-pressure generator. The spectrophotometric data then obtained having been taken away from the Bureau, reference could not be made to it until within the past few weeks. It now appears to the writer that the conclusions of a selective emission at ·7μ was unwarranted, although the data then obtained seem to indicate such a selectivity. The eye is not sufficiently sensitive to differences in intensity for frequencies beyond ·7μ to put much reliance in spectrophotometric observations. Moreover, from recent experiences with the spectrophotometer used, the writer feels that even a substitution method of comparison may not eliminate all errors. In the apparatus used by us the photometric field is not evenly extinguished by the rotating sector (in this device the sector is stationary and the beam of light is rotated), the line of extinction being from the lower right-hand quadrant to the upper left-hand quadrant. In the extreme red, the eye therefore unconsciously tends to wander from side to side, and inconsistent settings result. In some recent spectrophotometric work consistent results were obtained by fixing the eye on the central part of the photometric field. If the same conditions obtained in our acetylene comparisons the apparent selectivity is easily explained.

Suffice it to say that any selectivity of even a small part that recorded spectrophotometrically, could not, as will be noticed presently, have escaped detection, radiometrically. The radiometric observations at any spectrometer setting are in agreement to one per cent., which accuracy cannot be claimed with the spectrophotometer. As the one principally responsible in undertaking this work, the writer can but express his regrets that any one should be misled into a "discovery" of selectivity from the data then obtained. Other data then at hand were overwhelmingly against the spectrophotometric results and with the new data, to be discussed presently, the writer feels no necessity for changing the views then expressed,* namely, that the apparent spectrophotometric selectivity is due to an increase in transparency of the acetylene flame in the infra-red, and also probably to the fact that no correction has been made for luminosity.

The discovery* of this selective emission from an analysis of the spectral energy curves of acetylene determined by Stewart† can have but little meaning.

It is no reflection on Stewart's work to indicate that because of the limitations of the apparatus it would not have been used to settle a question such as the one now under discussion. The fluorite prism used had a small refracting angle and the whole visible spectrum (as the writer recalls seeing it) was only a few millimeters wide. Furthermore, the first published spectral energy curve is erroneous due to the improper slit-width correction, and especially due to the lack of knowledge of the absorption by the silver spectrometer mirrors, so that but little significance can be attached to a discovery of selectivity by an analysis of these curves which show no irregularities greater than allowable for experimental errors; and Hyde's computed black body temperature of 2050° C. does not prove the point in question. In this respect the present data are but a corroboration of Stewart's curves.

II.—Recent Experimental Data.

The data herewith presented are part of an extensive investigation of the spectral energy distribution of various illuminants, the results of which will be published in the near future. All the apparatus used was of special construction for this investigation, and hence the problem has been on hand for a long time. The spectrometer was of special construction, with planocurve telescope lenses of quartz 6 cm. in diameter and 18 cm. focal length, and a large 60° quartz prism. A light flint glass prism was also employed as a check on this work. The dispersion of the latter is almost three times as great as in quartz, which rendered

* *Bulletin Bureau of Standards*, Vol. V., p. 376 and 377, 1909.

* Hyde, *Journal Franklin Institute*, Vol. 170, p. 29, 1910.

† Stewart, *Phys. Rev.*, 13, p. 257, 1901; 16, p. 123 1902.

observation difficult in the violet. The light gathering power of this instrument is six times that used in previous investigations of acetylene. The dispersion is also considerably greater than used heretofore, being almost five times as great when using the glass prism. There is no uncertain absorption due to silvered mirrors. The instrument was capable of gathering in sufficient light and of producing a sufficiently long visible spectrum to make observation easy, accurate, and free from doubt. If a selective emission band of appreciable intensity exists at $\cdot 7\ \mu$ it must therefore be observable in the spectral radiation curve. Other instrumental details need not be entered into in this paper, and it will be sufficient to add that the radiation was measured by a Rubens thermopile of special construction. Because of the great light intensity, a high sensitivity was necessary and the galvanometer was used on a full period of only 5 seconds, corresponding to $i=2\times10^{-10}$ amp. Magnetic and thermal disturbances were inappreciable. In fact, with this apparatus far less difficulties were experienced than in the general infra-red investigations; which is just the opposite from what was expected before undertaking the work. To be able to make a reading in 5 seconds instead of 5 to 10 minutes, as was necessary heretofore is an important item, especially when examining an open flame subject to various fluctuations in the surrounding conditions.

From the fact that the galvanometer did not have to be forced to its highest sensitivity it is not to be inferred that spectral energy curves in the visible can be easily observed with ordinary apparatus. The intensity in the yellow is about 400 times—and in the red ($\cdot 725\ \mu$) it is about 3,000 times that at $\cdot 38\ \mu$. On the larger mirror spectrometer using the small fluorite prism previously described, and the same galvanometer period of 5 sec., the Nernst glower gave a deflection of about 2,000 cm. at the point of maximum emission. With 6 times the light-gathering power, which obtains in this instrument, the deflections would have been 12,000 cm. at the point of maximum emission. With the present instrument using a quartz prism the intensity of maximum emission of the Nernst glower would be about 90,000 times that at $\cdot 38\mu$. For the present investigation, the acetylene was produced by a commercial automatic generator. The gas was piped from another building. It was burned as it came from the gasometer without additional drying, and hence was investigated as in previous experiments. For the flat flame, a Von Swarz "Perfection" acetylene burner was used. Its rated capacity is $\frac{3}{4}$ cubic feet per hour operated on a pressure of 7 cm. ($2\frac{1}{2}$ ins.) of water. A lava tip of a "Naphey" burner was also used. This consumed $\frac{1}{8}$ cubic feet per hour. It gave a cylindrical flame about 3 cm. high. Spectral energy curves of these two flames were also obtained when burning under a gas pressure of 10 cm. (4 ins.) of water. It was then found that the curves of the two flames coincided exactly when operated under the same gas pressure. No data were obtained of the cylindrical acetylene flame when burning under 7 cm. water-pressure. The observations on the flat flame show that for the same intensity in the violet the intensity in the red is greater on the normal water-pressure of 7 cm. than on the higher pressure of 10 cm. water. In view of the fact that the observations on the flat flame were made on different days with different adjustments of the flame before the spectrometer slit, further observations will be necessary to determine whether this is solely due to a variation in pressure or due to a variation in the thickness of the radiating layer. The effect observed is probably due to pressure, for the spectral energy curves subsequently obtained from the flat flame radiating into the spectrometer slit flat-wise and edgewise, under the same pressure, were coincident throughout the whole visible spectrum to $\cdot 8\mu$ in the infra-red. In these three series of measurements, using the quartz prism, no selective emission (which should manifest itself as a hump at $\cdot 7\mu$ in the spectral energy curve) could be observed either in the prismatic or the normal

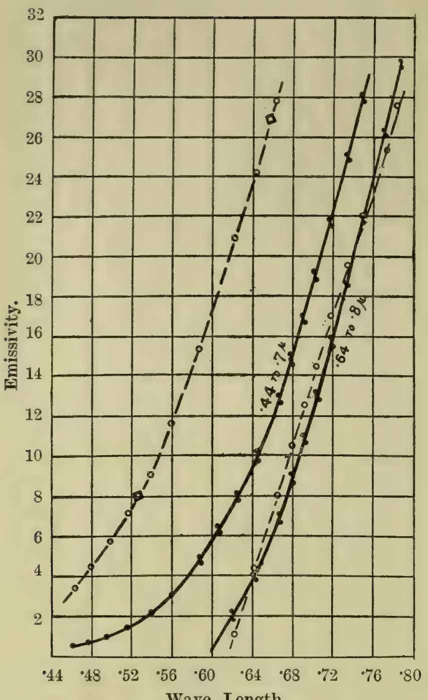


FIG. 1.

SPECTRAL ENERGY DISTRIBUTION OF ACETYLENE.

——— Prismatic Spectrum ; Glass •••

– – – – Normal Spectrum { Quartz □ □ □ / Glass o o o

curve. The apparatus was therefore readjusted and a light flint silicate prism substituted for the one of quartz. With this large dispersion, using the rest of the apparatus as before, the galvanometer deflections were reduced to 5 cm. in the yellow and a total deflection of 35 cm. in the red. For accuracy in measuring the galvanometer deflections all readings were reduced to about 15 cm. and, since the deflection could be read accurately to 0·3 mm. or 0·5 mm., a precision of a part in 300 to 400 would easily have been possible. But the flame was subject to fluctuations, due to air currents, of 1 to 2 mm. so that this precision was considerably reduced. The results obtained are shown graphically in Fig. 1, in which the continuous lines give the observation in the prismatic (glass) spectrum and the dotted lines give this same data reduced to the normal spectrum. The normal spectral energy curve of the flat flame obtained by using the quartz prism, coincides, within 1 per cent., throughout the whole length of the normal curves given in Fig. 1.

This is an excellent test of the factors used in reducing the prismatic curves to the normal curve.

(*To be continued.*)

Dies for Squirting Tungsten Filaments.

MR. G. S. MERRILL, in a paper before the American Institution of Electrical Engineers, gives some account of the difficulties in squirting fine tungsten filaments.

The die used, he says, consists in a small diamond, mounted in a steel casting, and having a hole drilled through it which, in some cases, is only 0.0014 in. in diameter. The tungsten paste is forced through this small hole at an enormous pressure, 32,000 lbs. per square inch being a usual figure. Mr. Merrill explained that this pressure causes very rapid abrasion of the die, and a constant increase in the diameter of the hole. Moreover, as the abrasion is not uniform, the hole enlarges more rapidly across one diameter than the other, and thus becomes elliptical in shape. This is a serious matter, for after about 1,500 filaments have been squirted, it becomes necessary to rebore the die, an operation which is very expensive, and cannot be repeated more than twice on the same die without developing cracks or fissures.

Sapphire has been tried as a material for dies, but with even less successful results, for in this case the die needs redrilling after about 100 filaments have been squirted.

The Advantages of Low Pressures for Metallic Filament Glow-Lamps.

THE choice of pressure to be adopted for a particular system of lighting must naturally depend somewhat on the local conditions, but the following points, taken from a recent number of *L'Électricien* (Aug. 13, 1910) and elsewhere, may serve to bring out the chief advantages of employing a low tension in the case of metallic filaments, and the devices to which this fact has given rise.

The main consideration is that low tension makes possible the use of short and thick filaments, which possess greater durability. Quite apart from the greater mechanical strength of a thick filament, the current consumption, for a given surface temperature and output of light, is said to be actually less than when using a thin filament. Now the life of a lamp is partly a question of blackening of the bulb; this again depends on the surface temperature of the filament. Hence the smaller current consumption referred to means an increased efficiency with the same length of life. Another advantage of the thick filament is its greater capacity for heat. This constitutes a sort of inertia, which tends to diminish the amplitude of the temperature wave due to the oscillations of alternating current at a given frequency. It has been shown quite recently that at 10 or 11 volts a perfectly steady light can be obtained by working with a metal filament lamp having a consumption of 1·5 to 1·7 watts per candle, and with a frequency as low as 15 reversals per minute. This suggests the possibility of applying to lighting the low frequencies which have hitherto only been suitable for traction.

There is another interesting point, peculiar to tungsten lamps, in connexion with this temperature inertia of thick filaments. The surface temperature of the filaments of these lamps, working at 1·1 watts per candle, is about 1700° C. Now the maximum value of the voltage in alternating current is at least $\sqrt{2}$ times the R.M.S. value, and on peaked waves might be considerably more. Hence at a given moment in the wave the temperature of the filament must be considerably higher than 1700° C., and may even approach the melting-point of Tungsten (2200° C.). It is suggested that this may account for the corrugated form which filaments assume after working on alternating current; there may be periodical softening as the melting-point is approached. Clearly it is an advantage to increase as much as possible this calorific inertia, so that whilst using very high temperatures for economic working, the filament should not be carried too near the melting-limit.

To gain the advantages set forth above requires that lamps should be run at a pressure of about 20 volts, and this is clearly out of the question for a public supply. There are, however, three ways of overcoming this difficulty :—

(1) By wiring lamps in series. This method is attended with certain difficulties, chiefly on account of the inequalities of lamps as regards diameter of filament and specific resistance. If two lamps are not accurately "paired," as regards current and specific consumption, one of them is apt to be overrun and rapidly gives way. Moreover, it would still be impossible to use really low voltages, as the number of lamps to be run in series would be too great.

(2) By using step - down transformers. Naturally this method can only be used on alternating current systems, but when this is the case it is often worth while to work off transformers even from such low pressures as 110 volts, and on higher voltages the advantages will be all the greater.

MM. Blondel and Weismann recommend placing the transformers as near the lamps as possible, *i.e.*, between each group of lamps and the controlling switch. This is mainly because the variations in pressure due to transformer losses are then less than if a single transformer were used for an installation. In addition the transformer can be switched on and off with the group of lamps fed by it, and so always used at full load and under efficient conditions.

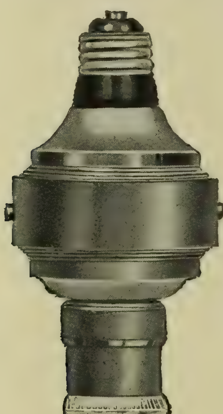


Fig. 1.

We may note that this principle is carried still further in the arrangement recently brought out by the A.E.G. Co., according to which each lampholder has a small transformer built into it, making a very compact arrangement, as shown in Fig. 1. By this means no-load or light-load losses are entirely avoided.

(3) A third, and somewhat novel method, has been recently described by De Kermond, also in *L'Électricien.* It consists in using a series-parallel system of wiring, as shown in Fig. 2. Any given illumination would be carried out by using a large number of low candle-power lamps, the voltage of which might be one-sixth or one-eighth of the supply voltage.

The great advantage of the system is that if one lamp fails none of the others are affected, or at least only to the extent of a slight increase in the applied voltage; moreover, the faulty lamp can at once be localized.

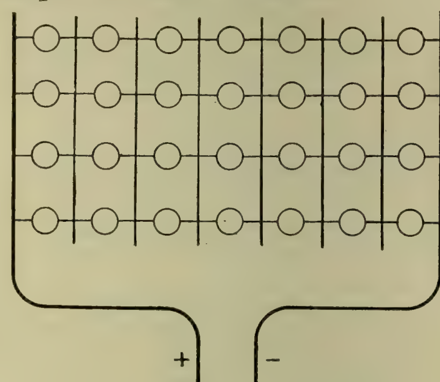


Fig. 2.

To take a practical example, in an installation of 240 14 c.-p. lamps, working on a 110 volt supply, 8 similar groups of 30 lamps each would be wired in series. In this case the failure of one lamp would only raise the voltage on the remainder by approximately 3 per cent, which would be inappreciable to the eye, and would certainly not endanger the lamps.

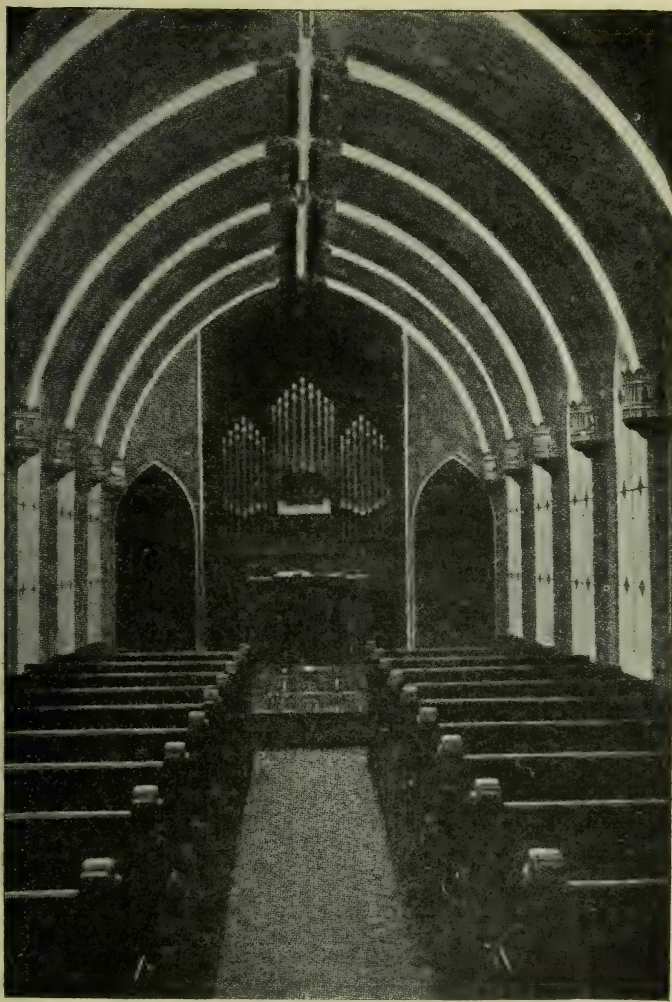
This method of grouping might naturally allow of considerable economy in the special case of illuminated signs.

The Moore Light.

A recently-issued number of the *Transactions* of the American Illuminating Engineering Society contains a paper on the Moore Light by its inventor, in which he reviews the progress that has been made since the invention of the "vacuum tube" light of 1894, and again suggests the adoption of the Moore CO_2 light as a standard of colour values.

The illustrations given in the paper show, in an interesting manner, the adaptability of the Moore Tube to the architectural features of a building. The view reproduced on the opposite page of the lighting of the "Moore Chapel" at Madison Square Garden, which was installed as far back as 1898, is a good example of what can be done in this direction.

The paper also describes a device called a "lumichromoscope," which forms a simple means of studying the colour value of various lamps. In this apparatus, lengths of coloured ribbons, *e.g.*, red, green and blue, are stretched in parallel lines on a board, and immediately above them the various easy to determine what change is caused by a lamp in the colour which it is used to illuminate. A table of results is given for a number of lamps, including arcs, Nernst, metal and carbon filament incandescent lamps, incandescent gas and ordinary fish-tail burners. The Moore light is claimed to



Lighting of the "Moore Chapel," Madison Square Garden.

lamps which it is desired to test are placed, each in a separate compartment, so that different sections of the ribbons are illuminated simultaneously by them. The effect of the light on the colour can be viewed from the side which is left open. In this way it is be the only one which does not cause any perceptible change in the colour of the ribbons when compared with daylight illumination, and it is on this ground that the author has advocated that it should be adopted as a standard for colour values.

A Comparison of Different Methods of Electrical Indoor Illumination.

By Dr. B. Monasch.

The inverted system of lighting has recently come to the front, especially in connection with the use of tungsten lamps, and it therefore occurred to the author that a table summarizing a series of researches recently made with the object of comparing the efficiency of direct and indirect lighting by incandescent and arc-lamps* might be of interest. It may be added that in this comparison the method of testing advocated by the Verband Deutscher Elektrotechniker was adopted. The intensity of illumination was measured throughout in a horizontal plane one metre above the floor and the results are expressed in terms of Watts per lux per square metre illuminated. It is also of interest to note that in the tests the system of comparison on the basis of *illumination provided*, instead of candle-power, has been adopted, and this seems to be the most rational method of making comparisons of direct and indirect systems of lighting, the Moore Tube, and other systems in which we are concerned with very extensive light-emitting surfaces.

Specific Consumption of Various Systems of Illumination for Interior Lighting.

Nature of System.	Sources of Light Used.	Specific Consumption (Watts per lux per sq. metre).
Indirect Lighting	Continuous current open arc lamps with ordinary arrangement of carbons	0·188 to 0·303
	Continuous current open arc lamps with ordinary carbons but inverted (—Upper+lower)	0·136 to 0·220
	Alternating current open arc lamps using ordinary carbons	0·339
	Tungsten metallic filament lamps (continuous and alternating current)	0·259 to 0·318
Semi-Indirect Illumination	Continuous current open arc lamps with ordinary arrangement of carbons	0·15 to 0·35
	Continuous current enclosed ordinary carbon "Economy" arc lamps (5 amp.)	0·367
	Tungsten metallic filament lamps (continuous and alternating)	0·225 to 0·260
Direct Illumination	Open continuous current arc lamps	0·15 to 0·3
	Carbon filament incandescent lamps	0·5 to 1·2
	Tungsten metallic filament lamps (clear glass bulb)	0·15 to 0·175
	,, ,, ,, ,, (frosted)	0·22 to 0·25
	Moore vacuum tube light, alternating current (measuring plane one metre above the ground)	0·445

* See also *Elektrotechnische Zeitschrift*, 31, p. 807, 1910.

NOTES ON THE PROCEEDINGS OF SOCIETIES, &c.

The Illuminating Engineering Society.

(FOUNDED IN LONDON, 1909.)

As announced in our last number, the opening Meeting of the Illuminating Engineering Society for the forthcoming session will be held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.), at 8 p.m., on TUESDAY, NOVEMBER 8th, when a paper will be delivered by Mr. F. W. GOODENOUGH, M.Inst.G.E., entitled "Recent Advances in, and the Present Status of Gaslighting."

The President, Prof. S. P. THOMPSON, D.Sc., F.R.S., will be in the chair.

Queries in Connection with Gas Lighting.

In view of the rapid progress made and the many different forms of lamps and appliances now available in connexion with gas lighting we have prepared the following list of queries dealing with points on which more definite information would seem to be valuable.

We contemplate submitting this series of inquiries to authorities on gaslighting in this and other countries, from whom we hope to receive much useful information:—

1. What is the maximum efficiency (candle-power per cubic foot of gas consumed per hour) attainable in practice at the present time, and under what conditions as regards pressure, &c.? What do you consider the most accurate method of expressing this quantity (*i.e.*, in terms of mean spherical, mean hemispherical or candle power in some prescribed direction)?

2. How long, on the average, should mantles intended (1) for low pressure indoor lighting, (2) for outdoor high pressure lighting, be allowed to be used before they are replaced? How much should their light be allowed to decrease before renewal, and how is this tested? Results of tests of the fall of candle-power during life of modern low and high-pressure mantles would be welcomed.

3. Under what conditions, in your experience, has automatic control of street lamps been found economical and reliable?

4. How far has it been found beneficial for the company to supervise the conditions of lighting enjoyed by the consumer, undertake the adjustment and cleaning of burners, globes, &c., and the replacement of mantles; should companies also give advice as to the location and use of lamps? In your experience is it the practice of companies, in buying mantles, to require compliance with a certain specification and what terms does it contain?

5. In view of the greater intrinsic brilliancy of modern high candle-power lamps is it desirable that some form of diffusing globe should be employed to screen high-pressure lamps in the streets and interiors?

The Fourth Annual Convention of the Illuminating Engineering Society (U.S.A.).

THE Fourth Annual Convention of the Illuminating Engineering Society in the United States is to take place at the Johns Hopkins University of Baltimore, U.S.A. on October 24th and 25th. An interesting series of papers will be presented and an attractive social programme, including an automobile ride through the beautiful suburbs of the city, has also been arranged. Readers of this journal will join us in wishing our friends in the United States a thoroughly successful and enjoyable gathering.

The following is the provisional list of papers to be read on this occasion :—

V. R. Lansingh, Holophane Company, New York.—'The Value of Illuminating Engineering to the Manufacturer.'

John F. Gilchrist, Chicago, Ill.—'Practical Value of Illuminating Engineering to the Central Station.'

W. J. Serrill, United Gas Improvement Company, Philadelphia, Pa.—'The Value of Illuminating Engineering to the Commercial Man.'

J. S. Codman, Boston, Mass.—'Illuminating Engineering Sheets for the Calculation and Recording of Data.'

C. F. Oehlmann, Denver Gas and Electric Company, Denver, Col.—'Central Station Illuminating Engineering Department Work and Methods Applied by the Denver Gas and Electric Co.'

Norman Macbeth, Welsbach Company, Gloucester, N. J.—'The Relations between Pressure and Light Output with Various Gas Lamps and Burners.'

J. G. Felton and E. J. Brady, United Gas Improvement Company, Photometrical Laboratory, Philadelphia, Pa.—'The Temperature Rise Due to the Energy Radiated in the Lower Hemisphere from Different Light Sources.'

Dr. Herbert E. Ives, National Electric Lamp Association, Cleveland, Ohio.—'Some Spectral Luminosity Curves Obtained by Flicker and Equality of Brightness Photometers.'

Preston S. Millar, New York Testing Laboratories, New York. — 'An Unrecognised Aspect of Street Illumination.'

Prof. S. O. Mast, Goucher College, Baltimore, Md.—'The Effect of Light on the Movement of Lower Organisms.'

Following the Convention there will be a series of 36 lectures delivered at the Johns Hopkins University dealing with different aspects of illuminating engineering. We have already published an account of this unique course of lectures, which are by recognized authorities in their respective subjects, and pointed out the valuable precedent set by concerted action of this kind. In the official notice now before us, the object of the course is fully explained and we cannot do better than quote the remarks made on this point :—

"The Illuminating Engineering Society recognizing the fact that there is an increasing demand for trained illuminating engineers and that the present facilities available for the specialized instruction required are inadequate, determined through an act of the Council of the Society, to encourage the establishment of a course of lectures on the subject of illuminating engineering. This course should have three objects : (1) to indicate the proper co-ordination of those arts and sciences which constitute illuminating engineering ; (2) to furnish a condensed outline of study suitable for elaboration into an undergraduate course for introduction into the curricula of undergraduate technical schools ; and (3) to give practising engineers an opportunity to obtain a conception of the science of illuminating engineering as a whole.

Inasmuch as such a course is most appropriately given at a University where graduate instruction is emphasized, and as the Johns Hopkins University has regularly offered courses by non-resident lecturers as part of its system of instruction and is now preparing to extend its graduate work into applied science and engineering, an arrangement has been affected by which the lectures will be given at this University under the joint auspices of the University and the Illuminating

Engineering Society. The subjects and scope of the lectures have been proposed by the Society and approved by the University. The lecturers have been invited by the University upon the advice of the Society.....

The University will provide facilities for demonstrations at lectures and will also have installed a working exhibit of apparatus for experimental work in light, illumination, and illuminating engineering. This apparatus will be at the disposal of those who attend, and an opportunity will be afforded to undertake laboratory work during the term of the lecture course under the supervision of trained experts of the University and of the Society.

A fee of $25,.00 will be charged for admission to the course and to the accompanying laboratory instruction. The complete course of thirty-six lectures will be given between the dates October 26 and November 8, 1910, inclusive."

The Visit of the German Institution of Gas Engineers.

A PLEASANT incident during the past month has been the visit of the German Institution of Gas Engineers, a very full and admirable account of which is given in *The Journal of Gas Lighting* for October 11th. We feel sure that the six days' visit, spent partly in England and partly in Scotland, must have been most enjoyable to the visitors, and they have carried away with them assurances of the good will and desire for mutual co-operation on the part of engineers in this country.

On Monday, October 3rd, the visitors, under the guidance of the President of the Institution of Gas Engineers (Mr. Alex. Wilson), Mr. J. W. Helps, and other members of the reception committee, were driven in motor-cars to the Beckton, Kensal Green, and Fulham Gasworks. Here they were entertained by the Gas Light and Coke Co., and had an opportunity of examining the vast plant and processes under their control. Luncheon was provided at Beckton, when speeches were delivered by the Governor (Mr. Corbet Woodall) and Herr Prenger (the President of the German Institution of Gas Engineers). Subsequently the other works were visited, and the party returned to the Westminster Hotel punctually at 5.30 P.M.

In the evening the visitors were entertained by the Institution of Gas Engineers at the Hotel Cecil. The healths of the King and the Kaiser were drunk, and the success of both German and British Gas Institutions was toasted. Mr. J. W. Helps, in proposing the former toast, alluded to the kindness showed to English engineers during past visits to the great works at Mariendorf, Tegel, and elsewhere, and emphasized the benefit derived by the whole gas industry from the work of many of the great German chemists and gas engineers. Herr Prenger and Herr Kordt in reply expressed their appreciation of the welcome accorded to them in England, the mother-country of the gas industry, and their conviction that both nations would continue to help one another to attack the many unsolved problems in gas manufacture and lighting. Progress was now so rapid that it was almost impossible for one man to keep abreast of developments, and interchange of knowledge and experience was more than ever invaluable and essential. The President, Mr. Corbet Woodall, and Mr. Aspinall, President of the Institution of Mechanical Engineers, again struck the same note when he alluded to the desirability of co-operation between different societies, and the benefit derived by the assistance of the Chemical Society and the Institutions of Mechanical and Electrical Engineers. "For surely it was the healthy competition in the supply of light that first started those great efforts to improve the gas industry which had resulted in the growth of the demand by the public for the best possible illumination."

On Tuesday the visitors were enter-

tained by the South Metropolitan Gas Company, and welcomed by Mr. Charles Carpenter at the East Greenwich and Croydon Gasworks; Herr Prenger and Herr Kordt also placed a wreath upon the grave of Sir George Livesey in the name of the German Association. Opportunity was found to study the most recent advances in gas lighting in a number of the chief London thoroughfares. Subsequently the visitors departed for Scotland, and visited the gasworks in Edinburgh and Glasgow, where they were received by the civic authorities and Mr. W. R. Herring and Mr. Alex. Wilson respectively.

It only remains to be said that every one was impressed by the excellent organization of the excursions, and that no pains were spared to render the visits enjoyable.

In passing it is pleasant to note that among those who worked hard in assuring the success of the visit, there were several, like Mr. F. W. Goodenough, Mr. W. R. Herring, and others, who were members of the Illuminating Engineering Society. Special mention should be made of the services of Mr. R. Lessing, who at short notice had prepared an illustrated guide of the gasworks visited, which was much appreciated, and whose able translations of the speeches was a feature of the proceedings. Among the visitors it was also a pleasure to welcome Herr F. Göhrum, of Stuttgart, who will be known to our readers as a corresponding member of the Illuminating Engineering Society, Dr. Karl Bunte, the worthy son of a distinguished father, and many others holding important positions in the German Gas Industry.

A Proposed Opto-Technical Institute.

A very interesting meeting was held at Anderton's Hotel, Fleet Street, London, on October 17th, in order to consider the offer of the London County Council to erect an Optical Institute in Clerkenwell, to further the work initiated at the Northampton Institute. The meeting was attended by a number of opticians from the provinces as well as prominent London representatives of the industry and the general feeling was strongly in favour of giving full support to the scheme.

The matter was introduced in an able speech by Mr. James Aitchison, who explained the steps leading to the offer of the Education Offices of the London County Council, on Sept. 27th, to found a central Opto-technical Institute, the building of which would cost about £30,000. It was remarkable that whereas other trades and branches of engineering had their technical institutes, the very extensive industry of applied optics had at present no adequate central institution of this kind. Mr. Aitchison proceeded to allude to the valuable and appreciated work already done at the Northampton Institute, which served to show the demand for technical instruction in optical work, and also gave particulars of the facilities for instruction in optics in various Continental cities; in several of these cases, he mentioned, the initiation to the movement could be traced to the precedent set by the Northampton Institute. The speaker then went on to refer to the many fields of optical research in which more scientific methods and further information were needed and mentioned the subject of illumination as one which deserved to receive further attention at the hands of those concerned with practical applications of light.

In conclusion, it was pointed out that the object of the meeting was to extend its support to the broad principle that an Institute on the lines suggested was desirable. Questions of detail as to the exact nature of the work and equipment could be dealt with at a later stage.

Mr. Conrad Beck, who followed, pointed out that it was their facilities for detailed scientific research that had enabled Continental optical firms to make such great progress. Yet he believed that, granted equal opportunities, workers in this country were every bit as capable of originating

good work. He thought the industry was badly in want of a central institute such as that proposed, and gave his hearty support to the movement.

Mr. L. Gaster laid stress on the many problems encountered by those interested in lighting, on which more definite data were badly needed. There were many problems connected with the effect of light on the eye still awaiting solution. There was also very much to be learnt in connexion with the design of instruments for measuring light and illumination, all of which provided interesting illustrations of the application of the laws of light. He hoped that these matters would receive attention and appreciated the valuable work that might be done in this direction at such an Institute as that suggested.

Dr. W. Ettles likewise laid stress on the need for more definite knowledge regarding the effect of light on the eye. In his experience he had found that the equipment of laboratories, as regards optical appliances, was rarely sufficiently complete, and indeed a considerable portion of his salary, as a lecturer on the subject of physiological optics had been spent in making good deficient apparatus !

Other speakers followed, all of whom expressed their conviction of the need for the Institute. Reference was made to the great glass works at Jena as an illustration of what science, judiciously applied, could do.

Finally the following resolution was put to the meeting and carried unanimously :—

Resolution :—

"That this Meeting of Optical Manufacturers, Traders and others interested in the progress of the Optical Industry, heartily supports the suggested establishment of an Opto-technical Institute in Clerkenwell, to further the work which has been hitherto carried on at the Northampton Institute, and which has proved of great value to the Optical Industry."

Recent Advances in Optics.

(Notes on the Thomas Young Oration delivered by Prof. R. W. Wood before the Optical Society, Oct. 10, 1910.)

Two new and ingenious optical devices were described by Prof. R. W. Wood in his Thomas Young Oration delivered before the Optical Society (London) on September 30th.

The "Echelette" is a form of diffraction grating, in which the ruling is about ten times coarser than usual, and is produced by a crystal of carborundum. The metal is not removed by the crystal, but compressed into ridges and hollows. The carborundum has straight sides inclined at 120° ; by altering the position of the crystal when ruling, however, it is possible to make the sides of the groove equally or unequally inclined as may be desired.

The gratings thus produced are for heat waves what diffraction gratings are for light, and have been found more efficient than rock salt prisms in investigating radiant energy. Prof. Wood showed a number of radiation curves obtained by this means.

The other novel instrument described by Prof. Wood was a telescope in which the rays were brought to a focus by a mercury surface set in rotation so as to assume a parabolic form.

The mercury was contained in a dish 20 in. in diameter, mounted in such a way as to reduce friction to a minimum. With this object a magnetic drive was originally attempted, but abandoned in favour of a motor, the turning movement of which was transmitted through half a dozen fine elastic threads. In this way vibrations which would disturb the reflecting surface were avoided.

By this telescope infra-red rays are reflected in a really remarkable manner. A number of photographs taken by infra-red light were shown.

The International Electro-Technical Commission.

An unofficial conference of the Commission was held at Brussels in August last. Eleven countries were represented, and in all fifty-two delegates were present. The meetings were held in the Council Chamber of the Minister of Railways, under whose auspices the Belgian Committee was formed. The deliberations, which were presided over by Prof. Eric Gerrard of Liège, were in the nature of a preparation for the Plenary Meeting to be held next year.

Complete success attended this meeting. Although the Conference, being unofficial, was debarred from formulating precise conclusions, the discussions which took place resulted in very definite desires being expressed by the Conference for submission to the various committees affiliated with the movement. As these were arrived at unanimously there should be no difficulty in their being adopted officially next year.

The difficult question of nomenclature was discussed, and the very practical proposition of the German Committee adopted as being more likely to be productive of early international agreement than the plan hitherto followed. This proposal involved the adoption of a comparatively short list of terms, requiring definition, and all dealing with one particular subject, in preference to the alphabetical method of procedure. The French Committee, following in the steps of Ed. Hospitalier, having deeply studied the question of international symbols, advocated the adoption of general rules dealing with principles rather than the premature discussion of any long list of symbols. Some half-dozen rules of this description were adopted for submission to the various committees, in addition to eight symbols proposed by the American Committee. The Commission has also decided to take in hand the determination of a rule for the direction of rotation of vectors employed in electrical science.

The international rating of electrical machinery was much discussed, and this is sure to bear fruit later on. The only recommendations to the committees as yet formulated were in regard to defining the output. It is noteworthy that the Conference proposes the international watt as the unit of electrical and mechanical power, thus signalling the final departure from the historically interesting, but scientifically undesirable expression "horse-power."

Uniformity and Contrast in the Lighting of Rooms.

Illuminating engineering is evidently not being neglected in South Africa, and we note that a paper on the subject was recently presented at a meeting of the Royal Society in that country by Prof. H. Bohle, one of the corresponding members of the Illuminating Engineering Society. An abstract of this paper occurs in a recent number of *Nature*. The author emphasized the important influence of uniformity and contrast in the lighting of a room on the amount of light required, and also discussed the physiological effects of radiation, including the effects of ultra-violet rays.

He considered that when great uniformity prevailed, the amount of light necessary was largely reduced. For example, in a room with black walls, an illumination of 35 to 40 lux would be required, whereas white ceilings and light walls might reduce this value to 30 lux; when perfect uniformity, such as might be obtained with indirect lighting, was secured, even 20 lux would, in the opinion of the author, give complete satisfaction. In dealing with "glare," Prof. Bohle pointed out that this was mainly due to the fact that when the eye looks at an illuminant of great intrinsic brilliancy in front of a dark background, it tries to do two things at once—to open wide for the dark background, and to close up for the bright light. Naturally a feeling of discomfort is the result.

Proposed Optical Convention in London in 1912.

A MEETING of the Optical Convention Executive Committee was held on Tuesday, October 25th, in the rooms of the Chemical Society, to consider the desirability of holding a second Convention in the year 1912. On September 16th a letter was addressed to members of the Permanent Committee of the Convention asking for their views for the guidance of the Executive Committee; and later a similar letter, a copy of which is appended, was sent to a number of firms who took part in the Convention of 1905.

In view of the large number of favourable replies received, both from members of the Permanent Committee and from important optical firms, it was agreed by the Executive Committee that further steps ought to be taken, and on the motion of Dr. Glazebrook it was resolved that a meeting of the Permanent Committee, in which all members of the trade and others interested be invited to attend, be held some time in November to consider what action should be taken with a view to organizing an Optical Convention in 1912.

The time and place for this meeting will be announced as early as possible. The chair will be taken by Dr. R. T. Glazebrook, C.B., F.R.S., Director of the National Physical Laboratory, as Chairman of the Permanent Committee; and a statement of the principal matters to be brought forward for consideration at the meeting will be published in due course.

R. MULLINEUX WALMSLEY,
Chairman of the Executive Committee.
October 26th, 1910.

Opening of the New Generating Station at the Northampton Polytechnic Institute.

THE opening of the new electric generating station at the Northampton Institute, which was performed by the Chairman of the London County Council on Wednesday evening, October 12th, served to illustrate the progress that is now being made in the equipment of many of the Technical Colleges and Institutes in this country.

As mentioned in a booklet on the subject issued by the Institute, it has been felt for some time past that in order to equip the men who pass through the Institute for positions in practical electrical engineering, it is necessary to keep in close touch with the commercial world and to have in the laboratories examples of apparatus, and facilities for using it, under conditions such as obtain in practice.

It is with the object of carrying out this idea that the new generating station has been installed. It will supply light and power to the Polytechnic buildings, and should present to students—even if on a somewhat small scale—some of the problems which occur in a large commercial station.

The main features of the plant are two gas-driven sets, each consisting of one continuous-current generator and one high-voltage alternator in tandem. The supply of gas is obtained from two suction gas producer plants, or, in emergency, from the town gas mains. The switchgear includes high tension and low tension boards, and has been designed with a view to obtaining the maximum number of interchanges between the various units of the plant.

The whole installation could be seen in actual operation on the opening evening.

Current Topics.

By an Engineering Correspondent.

Frequent reference has been made in recent numbers of this journal to the value of good illumination in factories, and the useful work already done by the Factory Department of the Home Office in drawing attention to this point.

But it might be said with equal truth that in very many offices, technical schools, &c., there is a great need for the education of those responsible, on the subject of what constitutes good lighting. Naturally public feeling can only be gradually educated on these matters, but no doubt it will be found advisable, now that the idea is already more familiar, to organize popular lectures and courses of instruction on the subject. Many gas and electric central station engineers could testify to the keenness with which popular lectures on electric or gas lighting appliances are followed even by the non-technical public. It may be suggested that hitherto there has been somewhat too much stress laid on lamps and appliances and too little on the use of them. It is not yet sufficiently realized how valuable to a company is the insistence upon *illumination* rather than lighting and the attitude of readiness not only to supply illuminating apparatus, but to give useful advice to consumers as to how to benefit by it.

* * * *

Attention should be drawn in these columns to a new gas lamp of the well-known "Graetzin" type, recently introduced, which, though using gas at the ordinary pressure, is stated to give an average intensity of 1,050 candles. Until recently, attempts at such a high illuminating effect with low-pressure gas had little satisfactory result, and it is only lately that it has been possible to produce such a lamp commercially. Each lamp utilizes three burners provided with inverted mantles, and the Berlin authorities ordered no fewer than 500 of the lamps immediately. The candle-power of 1050 only requires 630 litres of gas per hour, or, approximately, one candle-power per hour is obtained with 0·6 litres of gas—a very economical result when the fact is taken into consideration that neither gas nor air is compressed for the purpose.

* * * *

The general adoption of the metallic filament electric lamps has had a marked influence on the finances of the Leeds Corporation electricity undertaking, which has, during the past year suffered a decrease in revenue, in spite of an increase in the number of consumers for lighting purposes. The latter is greater than for several years past, but the number of lamps installed, reckoned in the equivalent of 35-watt lamps (a measure of their consumptive capacity) shows a decrease of 0·6 per cent, owing to the replacement of carbon lamps by metallic filament lamps. The same cause is directly accountable for the reduction of nearly 12 per cent in the revenue from sales of current to private consumers for lighting purposes, instead of the considerable increase which should, in the ordinary course, have resulted from the more extended use of electric light. In the field of public street lighting, there is evidence from Leeds of the extended use of metallic filament lamps, which because of its greater economy has resulted in a diminished consumption of energy by 5·2 per cent, and a decreased revenue of 5·76 per lamp installed.

Short Notes on Illuminating Engineering.

From all Sources.

Dimming Lights in Churches.

An interesting development in church-lighting is mentioned in a recent number of *The Electrical Field.* In St. George's Military Church at Aldershot dimming resistances are utilized so that the lights as a whole can be gradually weakened as in a theatre, thus producing the requisite subdued illumination during the sermon, &c.

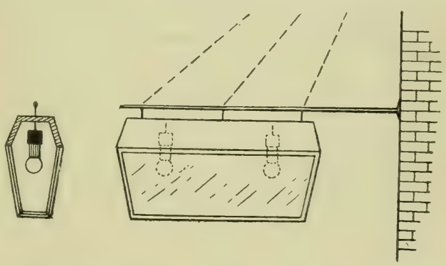
As a rule the method employed in churches is to switch off certain groups of lights during the sermon. This of course leads to an economy in current consumption, but the abrupt change in the light so caused is very noticeable and the distribution of light is also altered. By sacrificing a certain amount of power in a dimming resistance, it is suggested, a more artistic and gradual diminution in luminosity can be secured.

Impartial Evidence Wanted.

It would have been interesting had Professor Armstrong enlarged the scope of his paper, and given us some indication of the relative values of gas and electricity. Without any disrespect to the supply companies for those two products, it would be useful to have a more impartial account of the cost and uses of the two products than the deadly rivals can furnish us with. At present, they are far more occupied in pointing out the weak points in each other's armour than in strengthening their own. The wordy warfare is amusing, but somewhat inconclusive. — *The Globe*, Sept. 7th, 1910.

Flame Arc Lamps for Illuminated Signs.

The practice of hanging a pair of naked flame arcs in front of a shop-window is all too common, and the device shown in the accompanying illustration, and recently described in *The Electrical World*, might be studied with advantage by many London shopkeepers. It has the advantages of reducing the glare so distressing to passers-by, of ensuring a good illumination of the shop front, and of providing an attractively lighted



sign, without any increase on the present cost of energy. The device consists of a box-shaped transparent sign, illuminated from within by two arc lamps, the end opening towards the shop front being left open to allow the light of the lamps to fall upon the goods, without striking the eyes of the would-be purchaser. The sign should be mounted on a suitable bracket several feet away from the shop front in order to distribute the illumination effectively, and it is suggested that diffusing globes on the arc lamps would tend to improve the appearance of the sign by preventing concentration of the light on certain letters.

Illumination and the Efficiency of the Workman.

By far the largest part of the cost of any finished article is labour cost. To increase the efficiency of the labourer, or the human machine, is therefore first in importance in considering methods of reducing manufacturing costs. Two things contribute to this efficiency: machinery and facilities, and the skill and will of the operator. It is useless to expect a labourer to turn out his best work with poor tools. It is the part of economy to supply the best tools with the best facilities for using them, and among such facilities light stands first.

But the human machine must have the will to work, as well as the opportunity and facilities. This is partly conscious and partly sub-conscious. The conscious will is largely the result of the rate of wages; the sub-conscious will, which especially affects the quality, depends upon interest in the work, contentment with conditions and physical health, especially of the nervous system. The two latter conditions are dependent to a large degree upon light and ventilation. So that both from the material and the psychological view-points illumination stands foremost among the factors determining the efficiency of the human machine, and consequently the total cost of production.—*Electrical Review*, N.Y., Oct. 1st, 1910.

Animated Electric Signs.

Advertising by means of animated electric signs seems to have been brought to a fine art in America. *The Electrical World* describes a sign which has been used to display the merits of the "Uneeda" biscuit, and in which the cycle of changes is quite a long and complex one. First of all, a man's face appears with a very surly expression, eyes cast down, and mouth drooping. He is greeted with the words "Uneeda biscuit," at which he merely raises his eyes, still maintaining the expression of bad humour. The figure's hand then appears, holding a biscuit. The jaws close upon the biscuit, and the hand recedes carrying the remainder of it.

As the bite is masticated, a change comes over the face; the surly expression vanishes, and gives way to one of satisfaction.

The greater part of the movements outlined above are carried out by actually moving the lamps, and not by a flashing device, which would, on account of the time taken by an ordinary lamp to reach maximum brilliancy, be much too slow to give realistic effects. The scheme adopted when a line of lamps has to change its shape, is to mount the lamps on a spiral spring, which gives the required flexibility, and can be pulled by means of levers in any desired direction, the levers themselves being controlled by cams in order to secure accurate timing of the motions.

The actual movement of the lamps is, of course, combined with the usual commutator arrangement for cutting in and out certain lamps—as, for example, when the biscuit is shortened by biting!

Responsibility of the Architect in Lighting Matters.

It is a continual complaint with regard to interior lighting that even large and important installations are designed by an architect and builder who know nothing about gas, and no more about lighting than is comprised in certain rule-of-thumb formulae as to the sizes of windows, and the supply of material and fitting up of the same are let at the cheapest rate to some equally ignorant paper-hanger, painter, or plumber. If the result is not satisfactory—and under this system it is a mere toss-up as to how the job turns out—the architect has been forgotten, the painter has gone to another job, but the gas company are on the ground and they have to stand the racket.—*American Gas Light Journal*, October 10th, 1910.

Artificial Daybreak.

THE following is an account of the procedure followed at the recent opening of the New York Electrical Show in Madison Square Garden, which is described in a recent number of *The Electrical Review* as 'Artificial Daybreak':—

"After the garden has been filled the outer doors will be temporarily closed, and at a given signal all the electric lights will be extinguished simultaneously. After a few seconds of deepest darkness, it has been arranged to have one yellow light twinkle out from the eastern 'sky,' followed by another and another, until the east end of the garden takes on the appearance of dawn. Gradually the lights will show until the whole hall is again illuminated."

Side or Central Standards for Street Lighting?

THE new gas lighting of Victoria Street ....establishes beyond reasonable question that, even for the widest thoroughfares, side lighting is far superior to the axial position for the standards. It appears that the Corporation of the City of London are still halting between two opinions in this respect, with a tendency towards the axial arrangement, carried out by means of suspended lamps, for some of their narrower thoroughfares. If so, the example of Victoria Street should give them pause. Side-lighting facilitates vehicular traffic, especially as regards taking up and setting down, or loading up and unloading goods. With axial lights, however cunningly suspended in mid-air this work must be done in shadow. A tilt van backing up to the curb becomes a vault; and the labels, even the colour of omnibuses, are indistinguishable. Moreover, not enough light reaches the frontages for police purposes.—*Gas World*, Oct. 15th, 1910.

Light as a Burglar Expeller.

SOME time ago one of the engineers of Chicago's largest electric lighting company devised a system of emergency lighting for residences, by which the turning of a master switch at the head of the bed turns on the lights all over the house. These lights may be ordinarily operated by their respective switches in the usual way, but in case the master switch is turned on, they cannot be turned off by means of the individual switches. This means, of course, that once the master switch has been thrown, any intruder in the house must beat a retreat.--*Popular Mechanics.*

Gas Lamps to be Maintained by the Company.

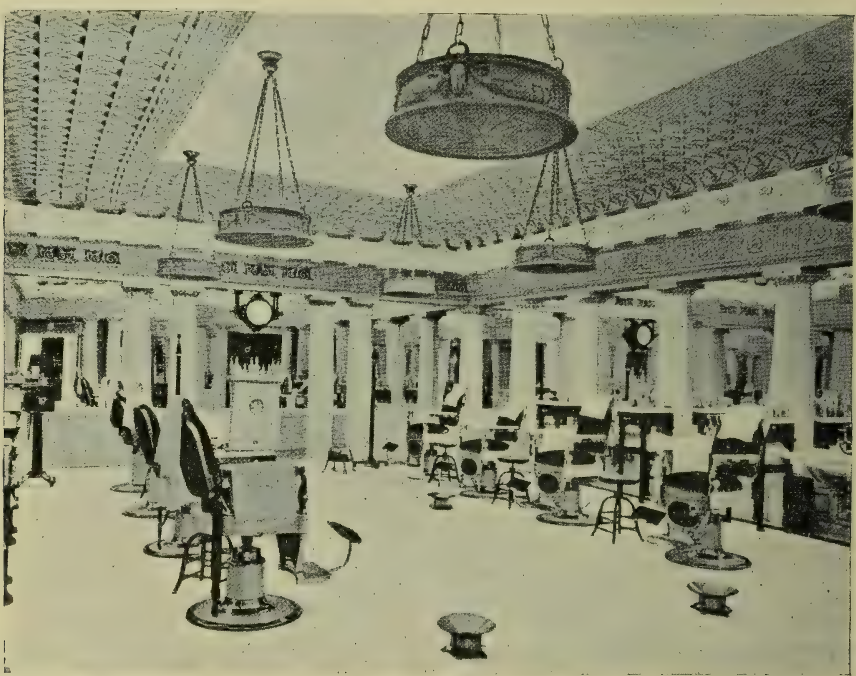
As precept is vain without practice, so also is canvassing without maintenance. At the present time gas undertakings are prepared to carry out the work of maintaining incandescent lights at such a nominal cost that it is to the advantage of every consumer to place his burners in their hands, as this procedure will result in his obtaining a far better light in the majority of instances than he could secure otherwise. Many consumers maintain their own burners, and do so excellently, and it would be well if all consumers could do so; but this is a counsel of perfection, and one which want of time and numerous other reasons render it impossible for most people to follow.—J. H. CANNING, *Gas World*, October 1st, 1910.

What Illuminating Engineering has done.

THE semi-dungeons in which thousands of people used to labour, with aching eyes and strained nerves, are happily a thing of the past; and this is due almost entirely to the propaganda of illuminating engineering, chiefly for commercial reasons....To be sure, this has not always been the work of professed illuminating engineers, but it has been the work of those who have at least been educated by the illuminating engineering profession to a recognition of the abuses of light.—*Illuminating Engineer*, New York, September, 1910.

The Illumination of a Barber's Shop.

The accompanying illustration shows the barber's shop in the Blackstone Hotel, Chicago. One is struck by the elegance of the fittings and the general magnificence of the interior, and the inverted fixtures used are also of interest, as another example of a method of lighting which seems to be becoming very generally used in the United States.



One feature of the installation here shown may be commented upon. One would suppose that the softness of the inverted system of lighting adopted would be particularly satisfactory to customers. One not infrequently finds that the barber, in considering his own requirements, pays little heed to the eyes of his customer ; for example, he instals lamps immediately above the client's head so as to throw a strong light upon his face while he is being shaved. But at the same time the light inevitably streams into his upturned eyes. In an inverted system this possibility of glare is avoided.

It will be noted that the light texture of the surroundings is well adapted to the diffusion of the light from this type of unit. The illumination of barber's premises is a matter of some consequence on hygienic grounds. The importance of cleanliness in this department was recently emphasised by Sir John Cockburn in his inaugural address at the recent congress of the Royal Sanitary Institute, and it is hardly possible that conditions of cleanliness could be maintained without the illumination being satisfactory.

The Progress of Modern Illumination.

An Interview with Prof. Dr. W. Wedding.*

The question of the scope and possible development of the large number of illuminants now available is a very complicated one. The lines of demarcation between the provinces of the different systems of lighting are constantly overlapping; many sources of light are now used in a way which would have been considered impossible a few years ago. It therefore occurred to us that an account of an interview with Prof. Wedding, which was published in a recent number of the *Oesterr. Ungar. Installateur*, would be of interest. Prof. Wedding is a recognized authority on gas and electric lighting. Lamps of all kinds are constantly being tested at his laboratories, and he is also known to our readers as one of the Vice-Presidents of the Illuminating Engineering Society. His comments on the situation at the present moment are therefore worthy of special consideration.

Future Developments.

The first question which Prof. Wedding was asked was as follows:—

In what direction do you anticipate the greatest development in the course of the next ten or fifteen years, gas or electric lighting? also in which of the two types of sources, small lamps for interior work and very powerful lights for outdoor lighting, is progress most likely to occur?

Prof. Wedding replied that he was inclined to think that the most striking modifications would be made in connexion with electric lighting, because in the case of gas lighting one was apparently at present confined to the use of the bunsen gas flame, the temperature of which is pretty accurately known. The chief direction of researches would naturally be to develop sources which produce light only, and not a large amount of inefficient and often inconvenient heat energy.

* *Oesterr. Ungar. Installateur*, September 17, 1910.

On the other hand Prof. Wedding thought that the future tendency would be to aim at distributing light, in small sources, rather than to aim at very powerful units. We have always been aiming at the production of more and more powerful sources of light, with the result that to-day we in many cases suffer from superfluity of light. We ought now rather to make efforts to produce a better quality of light and more uniform distribution, so as to resemble natural daylight conditions more closely.

Street-Lighting.

Prof. Wedding was next asked to give his opinion regarding the future of street lighting.

He replied, "as far as street lighting is concerned high pressure gas seems to me to possess very considerable advantages over other systems of lighting; by this means we can readily produce sources giving a light of several thousand candle-power. The arc-lamp already holds its position with difficulty against high-pressure gas and incandescent lamps even more so. Unfortunately, however, we have not yet achieved any absolutely safe and satisfactory method of automatic ignition. The cost of maintenance of gas now tends to play a more important part in the total expense than hitherto, and the advantage enjoyed by electric lighting—that one can extinguish and light up lamps with ease at a distance from the central station—is a very considerable one.

Recently attempts have been made in the United States to construct arc-lamps with almost indestructible electrodes which consume away very slowly. But most of these attempts have led to little practical result, for the light has been almost invariably unsteady and of peculiar quality in these cases. What is desired at the present day is, above all, constancy and steadiness."

Interior Lighting.

What system of lighting will, in your opinion, ultimately prove most satisfactory for interior lighting ?

"Electric lighting, where expense is not of much consequence ; but in the case of the poor man electric lighting is still too dear. It is true that the cost of electric energy is likely to become still cheaper, and that the metallic filament lamps will probably soon be improved very considerably as regards tendency to breakage. But their cost is still high for the great mass of consumers."

Prof. Wedding then proceeded to explain the difficulty experienced by electric lighting stations, owing to the fact that their plant can only be operated at full load for a few hours each evening, when artificial light is required. However, better results were obtained in manufacturing districts where a day load of motors, &c., could be secured. Prof. Wedding went on to suggest that a more uniform load might eventually be secured by including in the range of a single central station a very large district ; he contemplated the possibility that in future the whole country might be supplied from a single central station, the energy being carried by overhead wires at 100,000 volts, and transformed down where required. Stations of this kind could be erected near great turf-moors where unlimited fuel was available, or in the neighbourhood of water power, &c.

Limits of Present Efficiency.

Prof. Wedding was next asked : "What, in your opinion, is the limit of efficiency obtainable in the case of incandescent gas lamps, electric lamps, and arc-lamps ? "

He replied that the smallest specific consumption usually attained in the case of gas lighting had hitherto been in the neighbourhood of one candle per litre of gas per hour (28·3 c.-p. per cub. ft.). Yet in special cases a specific consumption of 0·6 litres per candle-hour (47 c.-p. per cubic foot) has been obtained, and the most recent results for inverted high-pressure gas had even given results as low as 0·4 (71 c.-p. per cubic foot of gas).

As regards metallic filament lamps, the limit of efficiency was still in the neighbourhood of 1 watt per candle, though researches were in progress with the object of producing a half watt per candle lamp. Practically all the metallic filament lamps now on the market utilized tantalum or wolfram as their main constituent. However, it was quite conceivable that other materials would soon be made use of, and in any case he thought the development of tungsten lamps was only in its infancy. It was safe to say that the fragility of these lamps would soon be overcome by some method, possibly by the use of special alloys of tungsten. An important announcement had now been made that pure metal tungsten could be drawn into wires, and it was claimed that a great improvement in durability could be secured in this way.

As regards arc-lamps Prof. Wedding thought the most important cheapening would lie in the production of lamps with simple mechanism and absence of clock work. By this means arc lamps costing only 20 to 30 marks had already been manufactured. Efforts were also constantly being made to turn out lamps in which the electrodes were automatically replaced as they burnt away, and this without any very complicated mechanism—for example, the Timar-Draeger and the Beck lamps.

As regards mercury vapour lamps, Prof. Wedding alluded to the introduction of the Quartz tube, for which a specific consumption as low as 0·2 to 0·25 watts per candle was claimed. Similar results could be secured with arc-lamps and in the Bremer lamp a value as low as 0·1 watts per candle was said to have been obtained.

The introduction of very powerful lamps on high masts has one disadvantage : it makes it desirable that such lamps should be lowered for cleaning. In the case of high pressure gas lamps this is particularly inconvenient, and special arrangements have to be provided in order to avoid the interruption of the gas supply.

Spread of High-Pressure Gas Lighting.

Commenting on the future of high-pressure gas, Prof. Wedding alluded to the enormous development of this system in Berlin where about 1693 lamps of the Grätzin pattern alone, yielding a total of nearly four million candle-power, were in use. In the provinces quite a quarter of the towns had been lighted by the Pharoslicht of the Auer Company, and the Millenium-licht had also found extensive application. At the moment the cheap price, steadiness, and high intensity characteristic of high-pressure gas gave it a great advantage in competition with arc-lamp lighting. Nevertheless, Prof. Wedding was disposed to suggest that in the future the tendency would be for all lighting to be ultimately carried out by means of electricity, whereas gas would come to be used more and more for heating and cooking purposes. On the other hand, he did not believe, whatever the future developments of illumination might be, that the gas industry, as a whole, would suffer. In any case, the process of conversion could only be very gradual, and the more extended use of gas for heating and cooking and other purposes would fully compensate for any reduction in the amount used for lighting purposes.

In answer to further inquiries Prof. Wedding made some remarks on the efficiency of light production and the desirability of producing a so-called "cold light." In the Tesla light there had long been available the basis of a source of this kind, and recently the practical development of vacuum tube-lighting on the Moore system attracted great attention in the United States and was now beginning to receive notice in Germany. Prof. Wedding emphasized one important feature of this system, namely, that it possessed a natural low intrinsic brilliancy, whereas in the case of other illuminants it was almost always necessary to tone down their brilliancy by the use of suitable shades and screens, &c.

Comparative Cheapness of Different Illuminants.

The question was then put to Prof. Wedding: "What, in your opinion, is the cheapest form of light for small uses?"

Cost of 100 Candlepower-Hours.*

Assuming cost of Electrical Energy, 72 Heller „ Gas, per cub.-metre, 24 „ „ Petroleum, per litre, 24 „	Heller.	*s.*	*d.*
Stearine Candle ...	165	1	4½
Carbon Filament Glow Lamp ...	25		2·5
Open Gas Flame Burner ...	24		2·4
Ordinary Petroleum Lamp ...	11·3		1·1
Tantalum Lamp ...	11·		1·1
Ordinary Arclamp, with Globe ...	10		1·0
Just (Metallic Filament) Lamp ...	7·9		0·79
Alcohol Incandescent Light ...	5·8		0·58
Upright Incandescent Gas Mantle ...	4		0·4
Inverted „ „ „ ...	2·2		0·22
Flame Arc Lamp ...	2·2		0·22
Petroleum Incandescent Light ...	1·1		0·11
Inverted High Pressure Incandescent Mantle ...	1·1		0·11

* The prices assumed for gas and electrical energy are higher than those prevailing in Berlin, where electricity is 48 Heller per K.W., and gas 16 Heller per cubic-meter.

He replied that the cheapest small unit was still the petroleum lamp, which only cost about "one heller" (0·1*d.*) per hour. The intensity of such lamps—10, 12, or 15 candle-power—was quite sufficient for the wants of small users. The portability of the lamp also constituted both a convenience and an added source of economy, since the source could be placed just where it was required. However, he said that such lamps

could not be considered as safe as electric lighting.

A considerable step forward had been made by the introduction of the inverted gas burner, which was now made to consume from 30 to 90 litres of gas per hour, and to yield 35 and 120 candles—almost twice as cheap as the ordinary burner. Naturally even more efficient results could be secured by high-pressure gas, while petroleum incandescent lighting was still cheaper. As an illustration of the running cost of various systems of lighting he gave the table seen on the previous page.

Hygienic Aspects of Lighting.

The last query related to the hygienic aspects of lighting. Prof. Wedding spoke of this as one of the most important questions in modern illuminating engineering. Apart from the possible effects of products of combustion from gas and petroleum, it was being now more fully appreciated that the human eye ought to receive special consideration. In interiors it was advisable to aim at a well-distributed illumination, and not merely the production of a large quantity of light. He thought that incandescent electric lamps, properly used, would be found very satisfactory from the hygienic standpoint. They could already be made to furnish a wide range of intensity, and could compete with arc-lamps of all but very high candle-power. In the case of arc-lamps, moreover, there seemed to be inevitably a certain want of steadiness arising through the working of the mechanism, and from the physiological standpoint perfect steadiness was very desirable.

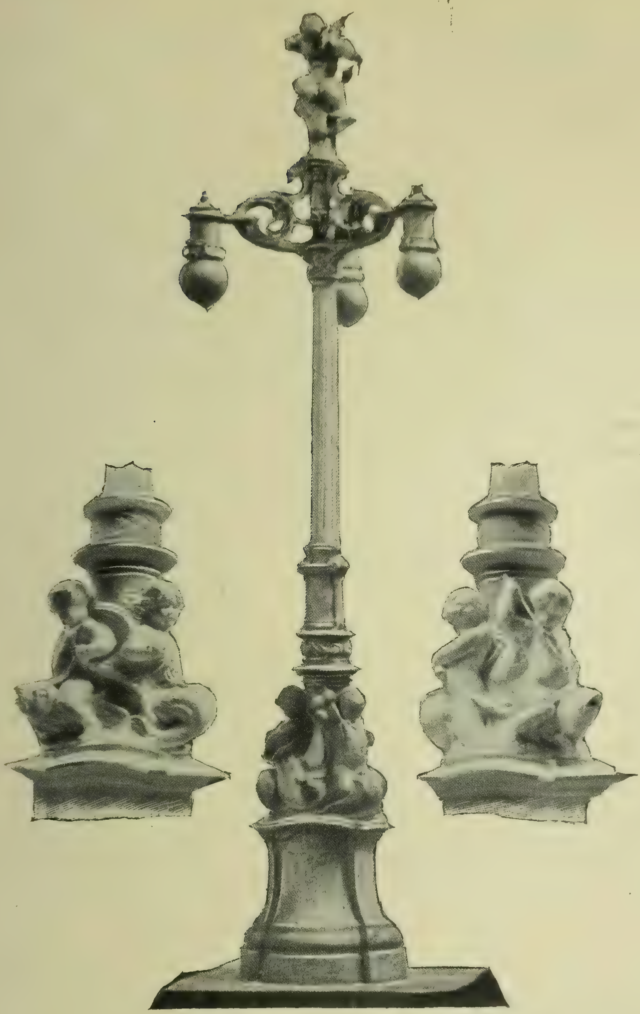
In conclusion, therefore, Professor Wedding recommended imitating daylight conditions by the distribution of smaller units rather than the use of concentrated lamps of high candle-power; it was also important to secure a source which resembled daylight in quality. Any peculiar colour, and particularly monochromatic light, must, he thought, be fatiguing to the eyes. Questions such as these would be bound to come to the front in the near future, and would be regarded as quite as important as cheapness and efficiency in the engineering sense, were felt to be.

Artistic Street Lighting Standards.

In an article* published in this journal towards the end of 1909, we had occasion to refer to some criticisms of street lighting standards, for which *The Builder* was responsible. In reviewing their æsthetic qualities the conclusion arrived at was "that most are more or less defective from the artistic standpoint," and that "something might perhaps be done in the future to secure more perfect conditions in this respect."

In this connexion, it is interesting to note that a fixture, designed by Mr. S. Nicholson Babb, and illustrated on the opposite page, is now being erected at the corner of the Horse Guards' Parade, near the Foreign Office. The lamp has a group of children around the base, symbolizing England's maritime power, and its artistic success may be judged from the fact that the design won, in open competition, a prize offered by the President and Council of the Royal Academy, who have since presented the standard to the Office of Works. We are indebted to the courtesy of the editor of *The Gas World* for the illustration reproduced here. It is not always easy to provide lamp standards which are both satisfactory from the standpoint of artistic appearance and constructional design, and also answer the requirements of the engineer, as to raising and lowering, and access to the lamps, &c. But it may well be suggested that much more might be done in this direction than at present, and there seems room for lectures on the subject by competent authorities and the organization of competition which might lead to valuable suggestions as regards design. No doubt facilities in these directions would be welcomed by engineers.

* *Illum. Eng.*, Vol. ii., p. 708.



[By the courtesy of *The Gas World.*

Ornamental Lamp Standard, designed by Mr. S. Nicholson Babb, and awarded a prize by the Council of the Royal Academy.

The Lighting of Westminster Cathedral.

In an article on 'The Illumination of Churches,'* which appeared in this journal early in 1909, reference was made to the lighting of Westminster Cathedral, and it was remarked that "The present temporary system of lighting by naked metallic filament lamps in use in the building, will no doubt subsequently be replaced by something more in keeping with its architectural pretensions."

It is worthy of note that massively designed fixtures, each carrying about 30 lamps, are now being hung from the great arches at the side of the nave. The lamps are not at present fitted with any shade, but they are, however, of the frosted type, which are naturally preferable to naked filament lamps. The cost, it is understood, will amount to about £2,000.

* *Illum. Eng.*, London, Vol. ii., Jan., 1909, page 44.

REVIEWS OF BOOKS.

The Application of Arc Lamps to Practical Purposes.

By Justus Eck, M.A., M.I.E.E.

(*S. Rentell & Co., Ltd.*, 36, *Maiden Lane, Strand*, 2*s.* 6*d. net.*)

This book is, as its sub-title indicates, "a manual for arc-lamp users," and it should prove a useful guide to many of those who wish to acquaint themselves with recent practical developments of the subject; these are dealt with in concise and readable manner, and the illustrations are clear and good. The book falls naturally into two main sections; the first eight chapters dealing with the various properties and applications of arc-lamps in general, whilst chapter nine is devoted to fully illustrated descriptions of the different types of arc-lamp now in use.

Following a short introductory chapter, the author deals with 'Light Radiation.' He points out that satisfactory illumination has been hampered in the past "from the desire of makers of different illuminating devices to compete on the question of brilliancy instead of suitability," and explains, further, that to have a powerful source of light is not much use without the knowledge of how to obtain the best illumination from it. In this chapter a number of polar and other distribution curves are given, and also tables and a diagram referring to spacing. Passing over the next two chapters on 'Efficiency' and 'Colour' respectively, we come to a collection of useful information in chap. v. This contains descriptions of a number of special applications of arc-lamps, such as photo-copying lamps, searchlight projectors, and lamps arranged for colour-matching. Diagrams of street lighting distribution are given, and reference is made to indirect lighting with inverted arcs. At the close of the chapter, the author deplores the tendency to lay excessive stress on "cheapness," which he thinks has greatly hindered progress in the direction of artistic electric light fittings.

Chap. vi. deals with connexions, and gives several useful diagrams. Chaps. vii. and viii. cover the subject of 'Installation and Maintenance,' and afford an opportunity to the author of drawing on his large experience for many practical hints. Chap. ix., as mentioned above, is mainly descriptive, liberal use being made of illustrations showing the details of the chief forms of modern arc-lamps.

How to Use the Electric Light.

By Frederic H. Taylor.

(*Percival Marshall & Co.*, 26–29, *Poppin's Court, Fleet Street, E.C.*, 6*d. net.*)

This little book is a guide for the consumer's benefit, written in non-technical language, and containing many suggestions as to what the user can do, in emergency or otherwise, to get the best efficiency from his electric light service.

A chapter on 'Correct Lighting' insists upon the importance of selecting lamps and shades carefully; we are glad to see that some of the principles of illuminating engineering are briefly explained, and that advice is given as to the use of shades and reflectors so as to distribute the light efficiently and screen undesirably bright sources.

'How to Read a Meter' is clearly information which might be useful to a consumer; it is also probable that the table giving actual examples of the cost of electric lighting in a number of houses of varying rentals will be found of considerable service by those who are in doubt as to whether their present lighting arrangements are too generous or the reverse. The book concludes with a brief chapter on electric heating; the table giving particulars of the various metropolitan supply companies, is also a serviceable feature.

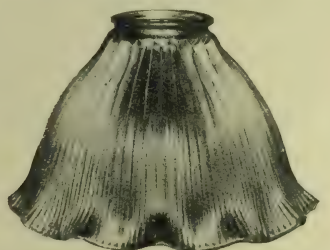
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

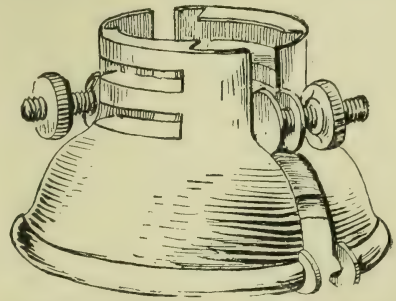
The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

New Holophane Reflectors.

We have received from **The Holophane Co., Ltd.** (12, Carteret Street, S.W.), a booklet dealing with their new standard line of Stiletto prism reflectors, the intensive form of which (Type I) is illustrated here. Full details, which include polar distribution curves, are given for each type of reflector, viz., the extensive (E) type, the intensive (I) type, and the focussing (F) type. There is also a note on the Holophane patent adjustable gallery, which enables the position of the lamp within the reflector to be adjusted so as to get the correct distribution curve, which can only be obtained in one definite position of the lamp. By this device, shown in the accompanying illustration, the varying positions of the filament in different makes of lamps, and for different voltages, is compensated for.



Holophane Stiletto Reflector. Intensive Type.



Adjustable Gallery for Holophane Reflectors.

The latter part of the booklet contains general information with regard to illumination, designed to assist the trade in taking full advantage of the Holophane system. It includes spacing rules, tables of illumination required in different circumstances, and information as to how this may best be obtained when using reflectors of the various classes.

"Tantalum" Lamp Tests.

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston, N.E.), have sent us the following particulars with regard to the testing of "Tantalum" lamps. The final testing department ensures good vacuum, correct voltage (so that any lamp may be used for either parallel or series burning), and correct candle-power. The method adopted for testing vacuum consists in using a large insulated metal cup connected to one terminal of a 10,000 volt transformer and fixed to a spring for facilitating its use. The lamps are then placed cap downward in a tray containing iron filings which is "earthed" (the other terminal of the transformer being also earthed), and the charged contact is applied to the bulb of the lamp at the pip end. If the bulbs fluoresce, showing presence of air, the lamps are taken out and returned to the Works for repair.

For correct voltage test the lamps are then placed in racks, each of which carries a large number of lamp holders, and the specified voltage for the batch of lamps in question is applied to the terminals of the lamps. Any lamp which is over brilliant or dull is removed to another rack carrying a higher or lower voltage as the case requires. On this test being completed the caps are cleaned by a machine and the correct voltage and candle-power stamped on each.

The lamps are then ready for the photometric test to verify that the candle-power of the lamp is precisely as marked on the cap. A special photometer room is provided for the use of inspectors or engineers wishing to make acceptance tests, fitted complete with the necessary regulating resistances, switches, and instruments, so that all lamps may be tested according to a specification.

It is claimed that these severe tests lead to exceptionally long life and durability,

Acetylene at the Machinery Exhibition.

One of the features of the engineering exhibits at the Naval, Mercantile, and General Engineering and Machinery Exhibition, held at Olympia, London, during September, was the display of acetylene lighting. A number of well-known firms exhibited. **Imperial Light, Ltd.,** 123, Victoria Street, London, S.W., had on show their storm-proof flare lights which, being self-contained, are specially well adapted for use in localities where gas and electricity are not available, for providing a strong light in connexion with buildings in course of construction, unloading at the docks, &c. Reference has previously been made to their use in this connexion in this journal.*

The Acetylene Illuminating Co. (268, South Lambeth Road, London, S.W.), who claim to be the pioneers of the oxy-acetylene industry, had a special exhibit demonstrating the use of the oxy-acetylene apparatus, for welding, brazing, and cutting purposes.

* *Illum. Eng.*, Lond., Vol. iii, July, 1910, p. 448.

The Thorn and Hoddle Acetylene Co. (151, Victoria Street, London, S.W.) had a display of the "Incanto" generators, flare lights, &c., and also an interesting exhibit of various artistic fixtures, lanterns, and imitation candles. Another item showed the welding of aeroplane frames by the "Incanto" system.

One other feature of the exhibit was the use of portable acetylene table and hand lamps equipped with generator complete, so that they could be stood on a table or carried about for inspection purposes as desired. One lamp of this kind, the "Carbec" table lamp of **Messrs. C. C. Wakefield & Co.** (27, Cannon Street, London, E.C.) involves the use of specially prepared compressed acetylene cakes by which, it is claimed, the tendency to deterioration in quality due to atmospheric moisture is avoided; as a result generation of acetylene only takes place when there is actual contact with water, and this is said to conduce to the safety of the process.

Gas Fires and the Smoke Nuisance.

The Gas Light and Coke Company report a considerable boom in the business of gas fire making, which is to be attributed to the great improvements made during recent years in the design of gas-stoves. These advances have increased the heat obtained whilst reducing the consumption of gas, and have included considerable progress in artistic design. It is suggested that we are getting quite appreciably nearer to, though still a long way from, the ideal of a smokeless city: a city of occasional mists, perhaps always; but some day, quite possibly, a city without fogs.

The Lighting of Airships.

It might be thought that the lighting of airships was a field hardly yet touched by the contractor, but we are informed by **Accumulator Industries, Ltd.,** that the "Leitner" system of automatic electric lighting, as supplied by them, is installed on the Clement Bayard Dirigible. It is also interesting to note, too, that the ill-fated America was equipped throughout with Holophane steel reflectors supplied by the **Holophane Company** of Newark, Ohio.

The Lighting of Victoria Street.

The new system of lighting Victoria Street by high-pressure gas lamps has now been completed, and the many thousands of visitors to London who arrive at the Victoria stations cannot fail to be impressed by their first experience of London street lighting while being driven along Victoria Street after dark—or rather one should say after sundown—for the new lamps, each rated at 2,000 candle-power, have vastly increased the illumination in what was previously a rather gloomy thoroughfare. The improvements that are constantly being made in high-pressure lighting should enable the gas lighting of London to compare favourably with that of the best lighted Continental cities.

Rain-Proof Cap for Electric Glow-Lamps.

An ingenious device for rendering an electric lamp proof against rain, when used for purposes of outside illumination, &c., has been put on the market by **Fred Wilkins & Bros., Ltd.** (54, Whitechapel, Liverpool). The difficulty up to the present has been that when lamps are used in the open air, and especially when set at an angle, rain gradually works into the holder and finally reaches the contacts. The new device consists of a small hood which effectually prevents the rain from getting between the socket and the cap.

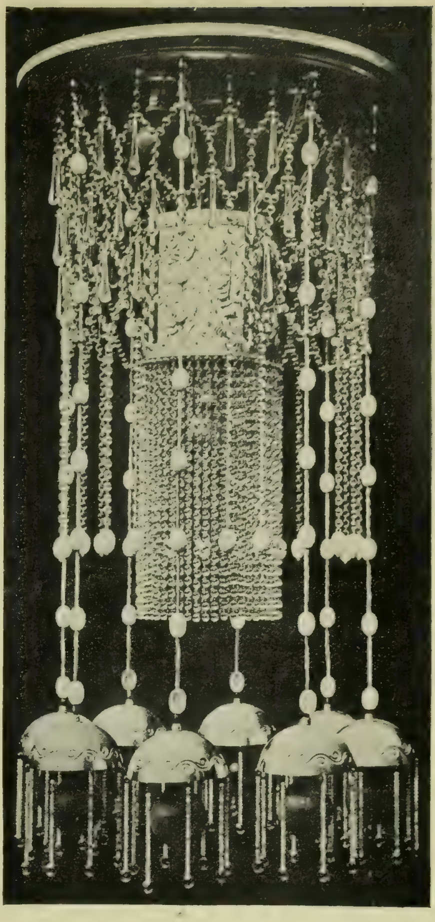
Mercury Vapour Converters.

We have received from the **Westinghouse Cooper Hewitt Company** (152, Great Saffron Hill, Holborn Circus, E.C.) particulars of the mercury vapour converters made by this firm for transforming alternating current. They are intended for use with projection arcs, for operating the electro-magnetic control on lifts, &c., for charging accumulators from alternating current supply, and other purposes where a uni-directional current is required, but would not otherwise be available.

The "Axis" Flame Arc Lamp.

The "Axis" lamp, illustrated herewith, is a form of flame arc lamp in which the carbons are mounted axially opposite each other instead of side by side; it is manufactured by the **Union Electric Co.** (Park Street, Southwark, S.E.). This design has been made possible by the use of special carbons, having a relatively thin enclosing envelope, and a large core, highly impregnated with light - giving salts. As exhibited in the polar curve, the illumination from the lamp is widely spread, with a maximum light emission at 35° below the horizontal. The lamp is therefore claimed to be very suitable for lighting large open spaces.

The "Axis" Flame Arc Lamp.



Decorative Pendant Fixtures.

The accompanying illustration shows a form of decorative hanging chandelier which seems to be commonly employed on the Continent, but utilized less frequently in this country. It is designed by the firm of **F. Klein** (Promenadeplatz 17, Munich).

The whole arrangement is based on decorative principles rather than designed from the point of view of strict efficiency, a liberal use being made of frosted and opalescent beads which glitter in an effective manner when seen by reflected light.

We are informed that the **Brockie-Pell Arc Lamp Co.** is now amalgamated with the **Foster Arc Lamp Co.**, under the title of "The Foster Engineering Co., Ltd." The new company will in future supply all apparatus made under the patents and rights of both companies.

Other Items.

From **Messrs. Falk, Stadelmann & Co.** (83–87, Farringdon Road, E.C.) we receive particulars of the Effesca metal filament lamps for the season 1910.

S. Heilpern (82, Hamilton Road, Longsight, Manchester), particulars of the "Unica" Accumulator Sediment Pump.

Union Electric Co. (Park Street, Southwark, S.W.) send us a copy of guide to the Brussels Exhibition, containing an account, illustrated, of the exhibits of Garbe, Lahmeyer & Co. The booklet concludes with a map of the exhibition.

From the **A.E.G. Electric Co., Ltd.** (133–5, Oxford Street, W.), we have received an illustrated list of their flame arc-lamps and arc-lamp accessories.

From the **Union Electric Co.** (Park Street, Southwark) a list of their "Union" direct current motors from ¼ to 50 h.p. Also particulars of a new show-card for the "Excello" flame arc-lamp.

Messrs. R. & J. Beck, Ltd. (68, Cornhill, E.C.), send us a pamphlet dealing with ordinary and diffraction spectroscopes, the latter being suitable for pocket use.

From the **Sun Electrical Co. Ltd.** (118–120, Charing Cross Road, W.C.) a descriptive catalogue of the "Sun" screwed tube system. Also an illustrated pamphlet dealing with reflectors, the "Sunlite" and the "Lumin-Ad."

Messrs. Siemens Bros. Dynamo Works, Ltd., Tyssen Street, Dalston, London, N.E., inform us that they have recently reduced their prices for carbon filament lamps to the trade, and will be pleased to quote higher discounts than formerly on the lamps catalogued in their price list 21 D.

The Imperial Lamp Works (Brimsdown) Ltd. (Kingsway House, Kingsway, W.C.), mention that they are prepared to send copies of their show-card, measuring 20 in. by 15 in., free of charge to all trade applicants on receipt of r equest.

Free Opal Reflectors.

We understand that the same firm have in hand a new advertising device in the shape of opal shades on which are sand-blasted the words "Tantalum Lamps." These opal reflectors will be supplied to contractors free of charge, for use on the lamp-holders in their premises.

Contracts Closed.

Messrs. Siemens Bros. Dynamo Works, Ltd., have obtained the contract for the General Post Office for "Tantalum" and "Onewatt" lamps. They have also secured a maintenance contract for the ensuing twelve months for "Onewatt" high c.-p. lamps for street lighting in Leatherhead and district.

Some Publications Received.

Elektrische Beleuchtung. By Dr. B. Monasch. (Verlag, Dr. Max Jänecke, Hanover.)

This is a new edition of a book previously reviewed in our pages.* It has been thoroughly revised and brought up to date, and, it may be noted, contains many additional references to articles which have appeared in *The Illuminating Engineer.*

Handbuch für den Besuch des Deutschen Verein von Gas und Wasserfachmannern. By Dr. Rudolf Lessing.

This little guide, which is excellently illustrated, records the progress of the gas industry, and gives details and statistics of the chief gas companies in Great Britain. The book was specially printed for the benefit of the German engineers recently visiting this country on behalf of the German Institution of Gas Engineers, and must have been found extremely serviceable.

Proceedings of the American Philosophical Society.—This number contains an article on 'The Effects of Temperature on Phosphorescence and Fluorescence,' by Prof. E. L. Nichols, to which we hope to refer in detail shortly.

The Physical Review.—An interesting article in this number by Mr. C. F. Brush deals with 'Photographic Photometry.'

Proceedings of the American Institute of Electrical Engineers.—There is a short report in this number of the discussion on 'Carbon Filament Lamps as Photometric Standards'—a paper which was abstracted in our September number.

Among other publications we have also to acknowledge the receipt of the following :—The Proceedings of the Physical Society, *The Journal of the Society of Architects*, *The Journal of the Royal Society of Arts*, *The Transactions of the South African Institute of Electrical Engineers*, *The Journal of the Franklin Institute*, *The Journal of the Western Society of Engineers*, *American Chemical Journal*, *Bulletin de la Société Imperiale des Naturalistes de Moscou*, &c.

* *Illum. Eng.*, Vol. i., p. 252.

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

A number of important items in this section have been either already noted elsewhere in this number, or deal with matter already familiar to readers of this (ournal, and therefore do not call for detailed comment. For example, in a recent number of *The Times* there is a full account of the proceedings at the SECOND INTERNATIONAL CONGRESS ON INDUSTRIAL DISEASES, in which the subject of illumination receives special attention, and in *The Times* Engineering Supplement for September 28th there is a general article dealing with practical results of the recent discussion on GLARE ; incidentally it is pointed out that the other extreme, shadowless illumination, is also not usually desirable. A paper by **J. S. Dow** and **V. H. Mackinney** on SURFACE BRIGHTNESS is fully noticed elsewhere.

The last number of the *Transactions* of the Illuminating Engineering Society in the United States is an important contribution to the literature of illumination ; some of the items have already received incidental notice in the press.

Thus **Dr. C. H. Sharp's** STREET LIGHTING REFLECTOR has already been mentioned. It is metallic of a somewhat peculiar shape, being expressly designed to throw as much light uniformly down the street as possible, and to avoid the waste of light distributed sideways ; a special form of the reflector can be effectively used to illuminate cross roads.

Some illumination tests by the same author and **P. S. Millar** deal with the part played by REFLECTION FROM WALLS in certain illuminated interiors. A paper by **L. R. Hopton** and **H. L. Watkins** in the same journal covers somewhat unusual ground. The authors discuss the connexion between DIFFERENT STYLES OF ARCHITECTURE and FIXTURE DESIGN, and the paper is very fully illustrated. **Dr. L. Bell** deals with STREET PHOTOMETRY. The main point brought out in this paper is the handicap under which photometric experts labour in taking tests in the streets by reason of the fluctuations in the sources of light. Arc-lamps notoriously vary very much, and even the incandescent light, Dr. Bell has found, may be subject to considerable variations according to the pressure. The photometrist must therefore attempt to strike a mean, but this entails considerable possibilities of error. It may be noted that Dr. Bell does not favour the flicker photometer for street work.

W. Wittek (*Elek. u. Masch.*, Oct. 9th) takes up the question of the most economical spacing and height of street lamps in order to produce a certain horizontal illumination. He shows that this problem is essentially different from that worked out by Uppenborn, on similar lines, and gives several practical problems to illustrate the validity of his conclusions.

It appears that in France the question of the illumination of signal lamps on trains is being taken up. M. Millerand, on behalf of the Government, has issued to several railways a suggestion that stronger lights are needed in the interests of public safety. The *Revue des Eclairages*, in referring to this matter, takes the same view. It is interesting to recall that in the United States exactly the opposite difficulty has been experienced, namely, that the signal lights on the locomotives were in some cases so brilliant as actually to interfere with the eyes of the drivers. The question of FATALITIES DUE TO DAZZLING LIGHTS, it may also be noted, receives reference in *The Illuminating Engineer* of New York for September last.

Turning to articles of a more technical nature, an interesting matter is brought up in an editorial in *The Electrical World* (Oct. 6). It appears that astronomers, in estimating the brilliancy of stars, are now falling back upon methods similar to those of illuminating engineers and expressing the results in terms of "candle-power per squ. cm." It is suggested that the old term "phos," originally suggested as a name for the unit of brightness proposed by M. Blondel in 1893, might profitably be revived.

ELECTRIC LIGHTING.

A recent editorial in *The Electrician* deals with the effect of metallic filament lamps on central station revenue. In several cases electric supply companies have decided to increase their flat rate, and this is deplored as unfortunate. Reference is made in the same journal to a recent report of the lighting department in Manchester where both gas and electric lighting are owned by the Corporation. In the circumstances most people will agree with the suggestion in the report that there is nothing to be gained by the two departments criticizing each other !

Other articles deal with applications of tungsten lamps. Thus in *The Electrical Review* (London), it is pointed out that a special variety of fixtures is being evolved to suit the High Power Incandescent Lamps, which are now becoming popular ; in these designs there are special points to be studied as a result of the size of units.

An interesting communication from **L. W. Dixon** describes the system of Street Lighting by Overhead Conductors at Dowlais (*Electrician*, Oct. 21). This is a method which has only rarely been applied in Great Britain where concealment of the mains was adopted by electrical engineers in the very earliest stages of lighting, but it is suggested that in country districts the method might be employed more frequently with advantage.

W. Hechler (*E.T.Z.*, Sept. 22) describes a new form of enclosed arc-lamps brought out by the A.E.G. In this case it appears that the deposition of fumes on the inner globe is sanctioned—within certain limits. But matters are arranged so that a wide zone of the inner globe near the arc itself rapidly approaches a temperature at which deposition cannot occur, and it is only the lower and more remote portions that gradually receive a deposit. By far the greater portion of the light is therefore unobstructed. A specific consumption of 0·34 watts per H.K. is said to be obtained.

Lastly special reference should be made to the electric Street Lighting Number of *The Electrical Times* (Oct. 14), which contains a variety of views of installations and deals with the subject on quite an extensive scale.

GAS, OIL, AND ACETYLENE LIGHTING, &c.

A serial article by **N. H. Humphreys** in *The American Gaslight Journal* surveys the present state of Outdoor Lighting in Great Britain. The author points out that there is a need for more attention to be devoted to the utilization of gas as apart from its manufacture. Some managers are still unenterprising in this respect.

A useful contribution is that of **M. C. Whitaker** (*T.I.E.S.*, May, 1910), who also summarizes progress in incandescent gas lighting. The author describes the most recent types of burners and gives pictures of the cotton, ramie, and artificial silk mantles. One specially interesting portion of the paper is that dealing with Automatic Ignition. The author shows that when electrically heated wires are used to kindle gas there are two effects ; the electric current heats the wire to a moderate glow, and then the catalytic action of the gas impinging upon it carries the temperature still higher to incandescence. There is, therefore, a certain range of temperature which is satisfactory and safe, but if the wire starts too hot it may ultimately melt with the increase of heat due to catalytic action. Hence the necessity for careful design in igniters of this class. Another very serviceable recent article in the same journal contains a summary of the advantages and disadvantages of the chief automatic systems of ignition of all kinds, clockwork, pressure, electrical, &c., as at present applied to public lighting.

W. Mayer (*J. f. G.*, Oct. 8) contributes an article describing researches on the much-discussed question of whether the illuminating effect of a mantle is proportional to the calorific value of the gas used. Past experiments on this point have led to many apparently conflicting results, but in reality this was due to the experiments being made under different conditions, and at present it seems hardly possible to trace an exact connexion between the two quantities such as could be relied upon in practice.

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung*
T. I. E. S.—*Transactions of the Illuminating Engineering Society* (*United States*).
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*

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The ILLUMINATING ENGINEER

ELECTRICITY · ACETYLENE · OIL · GAS

Edited by LEON GASTER

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EDITORIAL.

Recent Advances in Gaslighting.

On Tuesday, November 8th, the opening meeting of the second session of the Illuminating Engineering Society took place, a paper dealing with 'Recent Advances in Gaslighting' being read by Mr. F. W. Goodenough. The paper was followed by a very interesting discussion. As explained in our last number, the intention on this occasion was to give up the evening to a summary of progress in gaslighting, the understanding being that a subsequent evening would be devoted to a discussion on electric lighting on the same lines. It was also laid down by the President, on behalf of the Council, that the discussion should be of a non-controversial nature, and this proviso was cordially approved by those present and followed by all the speakers in the discussion.

At the commencement of his paper Mr. Goodenough laid stress on the important functions which a body like the Illuminating Engineering Society can fulfill, one of these being the valuable opportunity it affords for those connected with different systems of illumination to meet and exchange views on a friendly footing. We feel sure that Mr. Goodenough's contribution to the transactions of the Society will be read with the keenest interest, not only by those concerned mainly in gaslighting, but also by many connected with other systems of illumination. We can only refer to a few of the interesting points that arose in the paper and the discussion, and

refer our readers to the full account of the proceedings on page 715.

Besides giving his experiences to the practical performances of incandescent mantles under various conditions, Mr. Goodenough dealt with several points of special interest to the illuminating engineer. We may mention, for example, his account of the method adopted by lighting companies of judging and selecting mantles and burners, and his discussion of the means open to a company of helping the consumer to get the most from the illuminant he is using, a direction in which Mr. Goodenough himself has rendered signal service to the gas industry.

The question of the ability of consumers to adjust their own burners led to a very interesting announcement from Mr. C. Carpenter, who opened the discussion, of a new step taken by the South Metropolitan Gas Company. This consisted in the use of a type of burner which did not permit or necessitate adjustment of the air supply, the arrangements in this respect being standardised for the quality of gas used. Burners of this type are said to have given great satisfaction, and the simplicity of the method should prove very serviceable in view of the fact that not all consumers are willing or able to see that their burners are kept in proper working order, and to make the necessary adjustments.

There were many other points that gave rise to keen debate, one of them being the desirability of central suspension of gas-lamps in the streets, of which several speakers (including Mr. Goodenough himself) did not approve. Reference was also made by Mr. Carpenter and Dr. R. Lessing to the theory of the high efficiency of the inverted burner.

We should like to express the thanks of the Society to all those who contributed to the success of the evening, and especially to Mr. Carpenter for so kindly arranging to be present and open the discussion.

Independent of the paper by Mr. Goodenough, a series of queries connected with gaslighting were drawn up and submitted to various authorities in this and other countries in order to give the discussion an international character. This list was published in our last number, and is again reproduced on page 732 in this issue. Replies have already been received from several corresponding members of the society, including Prof. H. Strache, Mons. F. Lauriol, Mr. Scholz, and others, and will be found on pages 733 to 736. We hope that in our next number we shall be able to publish other contributions from authorities in the United States and elsewhere. In conclusion, we hope that this discussion has afforded an opportunity to members of the gas industry of assuring themselves of our desire to maintain a strictly impartial attitude and to treat all illuminants in an unbiassed manner.

The Fourth Annual Convention of the Illuminating Engineering Society (U.S.A.)

The Fourth Annual Convention of the Illuminating Engineering Society took place in the United States last month, and seems to have been as was expected, exceedingly successful. Unfortunately we cannot afford space in this number to do justice to the meeting as we should have liked to do, but we propose to deal with the matter in greater detail shortly. The Presidential Address delivered by Dr. E. P. Hyde, pleaded for a broad conception of illuminating engineering. A summary was also given of the present knowledge regarding the different qualities of radiation in various parts of the spectrum. Dr. Hyde mentioned that it was theoretically possible to secure a luminous efficiency of 300 lumens per watt for the case of white light, and 800 lumens per watt for yellow-green light—values which we are still a long way from realising.

Among other important papers presented we note that of Mr. A. J. Sweet, who advocated further study of the nature of the surfaces illuminated in street lighting, as well as the distribution of the illuminating sources. Prof. Ashe, Mr. Oehlmann, and Mr. Williams, of the Denver E. Lighting Co., all gave accounts of the education of employees in connection with illuminating engineering in their districts and testified to the importance now attached by lighting companies to facilities in this direction, and to securing a staff of specially trained men. Valuable papers on photometry and other subjects were read by Drs. H. E. Ives, L. B. Rosa, Mr. V. R. Lansingh, and others.

An important precedent was also set by the report of the Committee, concerned with nomenclature and symbols, which has been considering the question of the correct naming and significance of such terms as *intensity of light*, *lux*, *flux*, &c., commonly used in connection with lighting problems. We are confident that any decisions taken by this committee will be recognised as merely provisional and preparatory, in order to pave the way for discussion on the part of of representatives of the different countries concerned, and ultimate international agreement.

It may be added that the membership of the Society in the United States now exceeds 1,250. The constant increase in this direction should render the Society even more representative in character than in the past, and enlarge still further the scope of its work in bringing home the need for good illumination to the general public.

The Johns Hopkins Lectures in Illuminating Engineering.

We have already drawn attention to the important series of lectures which has just taken place at the Convention of the American Illuminating Engineering Society, and in this connexion it only needs to be said that the course has apparently fully justified its prospects of success, being attended by over 250 post-graduate teachers and others interested in illumination. As many of these will, in their turn, subsequently deliver lectures dealing with illuminating engineering, it can be seen how beneficial such a course may be in developing the movement on the right lines, and leading to the gradual evolution of men having the full qualifications of the illuminating engineer.

We have now received the final syllabus of the lectures. It includes more than forty pages of printed matter and affords further evidence of the scope of the course and the thoroughness with which the ground has been covered. We understand that the lectures will be subsequently published in two volumes, and should furnish a remarkably up-to-date and complete guide to all those interested in illuminating engineering.

Problems in Street Lighting.

We deal elsewhere with some interesting features in the new building of the Institution of Electrical Engineers, and the fascinating address delivered by the new President, Mr. S. Z. de Ferranti, at the opening meeting.

On November 24th, illumination was again to the fore, an interesting and suggestive paper on ‘Street Lighting’ being read by Mr. Haydn T. Harrison.

In our present number we complete the paper by Mr. A. J. Sweet on the same subject, and we postpone detailed treatment of this matter to our next number, which it will be recalled, is to contain Prof. E. W. Marchant's coming paper before the Illuminating Engineering Society and is to be devoted especially to progress in electric lighting.

There is one point, however, in connection with Mr. Haydn Harrison's paper, which deserves special emphasis. Many papers have been presented in

the past dealing with street lighting but in too many cases these resolved themselves purely and simply into an analysis of cost, the object being to prove that electricity is cheaper than gas or *vice versa*. In his paper, Mr. Haydn Harrison presents a considerable amount of information regarding the performances of various types of lamps, but he has also done good service by drawing attention to the illuminating engineering standpoint.

Nowadays it is becoming increasingly evident that the question of cost is only one important item. There are many other questions connected with the effect—the best positions of sources and their distribution, the most effective variety of illumination for certain classes of streets, &c.—which are rapidly coming to the front. Foremost among these is the very difficult problem of securing good distribution of illumination and yet avoiding glare, and it was significant that the discussion of Mr. Harrison's paper was largely devoted to this matter. For our part, we are convinced that in the near future the discussion of what constitutes good lighting will turn more and more on this question of avoiding badly-placed and inconveniently brilliant lights. The tendency in this direction is accentuated still further by the change in the nature of traffic and the increased speed of mechanically - driven vehicles. Conditions of lighting which dazzle the eyes of drivers and bewilder pedestrians might have been tolerated a few years ago, but are too dangerous to be acquiesced in now. It may therefore be anticipated that authorities concerned with traffic regulation will pay an increased amount of attention to street lighting.

What, however, was the most important item in the discussion was a proposal of Mr. C. P. Sparks, which we have long ago advocated, and which, we were glad to see, met with general approval. This was that a committee — on which electric and gas engineers, surveyors, and all concerned with the subject of street lighting should be represented — should be formed in order to deal with these problems of common interest to all concerned. We feel sure that this suggestion will receive warm sympathy and encouragement from the Illuminating Engineering Society, which has from the first recognized the need for agreement on such points, and, being impartial and international in its outlook, should be specially qualified to assist in this matter.

Illumination, its Distribution and Measurement.

In the last number we brought to a close the admirable series of articles which Mr. A. P. Trotter has been contributing to the *Illuminating Engineer* from its commencement in January, 1908. We feel that we cannot let this occasion pass without expressing our appreciation of this comprehensive series of articles, the regular appearance of which, month by month, at the commencement of each number, has been a familiar and appreciated feature of the journal by regular readers.

The high standard maintained in this series of articles and Mr. Trotter's reputation as an authority on matters connected with photometry and illumination has been of very great service to the journal, and we feel sure that they will remain a valuable source of reference for information on these subjects.

Readers will be glad to hear that it is anticipated that the material of these articles (with considerable additions occasioned by the most recent progress) will be issued in book form very shortly, and we shall await the appearance of this work with great interest. LEON GASTER.

Review of Contents of this Issue.

THE Technical Section opens with a message from **Mr. S. E. Doane,** Chief Engineer of the National Electric Lamp Association, in the United States, to illuminating engineers in this country. He lays stress on the importance of concerted action between those connected with different branches of lighting, and, as a special example, mentions the experience of the United States regarding the standardization of lamps and reflectors (p. 703).

Following this will be found a contribution from **Mons. P. Lauriol,** in which he describes the method adopted by the Lighting Department in Paris of TESTING A NUMBER OF INCANDESCENT MANTLES AT A TIME. The system involves the use of a photometer with a graduated aperture, and measurements are made on the "Double Comparison" method.

The paper by **Mr. A. J. Sweet,** on the ANALYSIS OF STREET - LIGHTING REQUIREMENTS, is completed in this number (p. 705). In the last section the author dealt mainly with the most effective methods of distributing light and securing uniform illumination in the streets. In the present number he is concerned mainly with the other great important factor in street-lighting —the avoidance of glare. He describes a series of tests in which the connexion between the intensity of glare and acuteness of vision is studied and relations are deduced between the glare and the candle-power, distance away of the source, and the angle at which its rays arrive at the eye. In conclusion Mr. Sweet makes a number of recommendations as to how the ideal result can best be obtained, one of the most important being that the ratio between the distance apart of the lamps and their height above the roadway should not be greater than 4, and that the angle with the horizontal at which direct rays from the lamp can reach the eye of pedestrians should not be greater than 30 degrees.

The next section of the magazine is devoted to transactions of the **Illuminating Engineering Society** (p. 711). This portion of the journal opens with a brief report of the last meeting of the society held on November 8th, and a list of the names of elected members, and of those who have applied for membership in the society, is published. An important item is the Report of the Hon. Secretary regarding the visit of delegates of the Society to the CONGRÈS INTERNATIONAL DES MALADIES PROFESSIONELLES, where influential support was received.

The paper by **Mr. F. W. Goodenough** on RECENT ADVANCES IN, AND THE PRESENT STATUS OF GASLIGHTING, which was read at the meeting mentioned above, is reproduced in full (p. 715).

The President, in introducing the discussion, explained that it was intended that the evening should be devoted to a non-controversial summary of progress in gaslighting. Subsequently a second evening in the session would be devoted to a corresponding discussion by electric lighting authorities, in which advances in this direction would be dealt with.

Mr. Goodenough refers to the important function exercised by the Illuminating Engineering Society in enabling engineers connected with different systems of lighting to meet on a common footing. Details are given of the efficiency and life of various classes of mantles in practice, and special reference is made to the progress in high pressure street-lighting. Reference is made to recent progress such as the use of non-collodionised mantles, by which the tendency to breakage of mantles is diminished, and materially improved results as regards life secured.

Photographs of recent installations in various main thoroughfares in London accompany this description. Mr. Goodenough also emphasizes the value of a "maintenance contract" to the consumer, who would otherwise run the risk of not keeping his installation in the most perfect condition.

This paper is followed by a complete account of the discussion at the meeting (p. 725.) The discussion was opened by **Mr. C. Carpenter,** Chairman of the South Metropolitan Gas Co., who discussed, among other matters, the theory of the improved efficiency secured through the use of inverted burners. Mr. Carpenter also made an important announcement regarding a new type of burner, which was correctly set for a given quality of gas and required no air regulation, and which had been recently introduced by the South Metropolitan Gas Co. with great success.

Mr. Chas. W. Hastings alluded to the need of keeping the supply-presssure at a definite value, and **Mr. W. H. Y. Webber** expressed his agreement with the lecturer to the effect that centrally suspended gas lamps were undesirable.

Dr. R. Lessing dealt mainly with the efficiency of the inverted burner, which was mainly a matter of flame-temperature. Important evidence of the conditions of combustion was furnished by analysis of the flue-gases.

Mr. W. J. A. Butterfield alluded to his experience of inverted mantles which had been very satisfactory, and pointed out that centrally suspended lamps in the streets might interfere with fire-escapes. **Mr. A. E. Broadberry** (Tottenham Gas Co.), predicted still better efficiency as the result of increased pressures. **Mr. S. E. Doane,** as a visitor from the United States, expressed his sympathy with the work of the Society, and **Mr. S. E. Thornton** (Chairman of Messrs. Sugg, Ltd.), suggested the desirability of paying attention to the illumination of the exteriors of buildings. **Mr. Edwards** (Aldershot Gas Co.), approved of central lighting in certain circumstances, and raised the question of how far non-adjustable burners could be utilized with a system of mixed gases.

The President made a few final remarks in the discussion, and Mr. Goodenough's reply will be found on page 729.

A number of Queries on Various Points Connected with Gas-lighting were also prepared and circulated among authorities on the subject. Replies from **Prof. H. Strache, Mons. P. Lauriol, Herr Scholz,** and **Mr. Geo. Keith** have been received and will be found on page 733. It is anticipated that contributions from other corresponding members will be published in the next number. Two recent contributions from **Mr. M. C. Whitaker** in the United States and **Herr Lebeis,** in Berlin are also dealt with. A particularly interesting note in the former paper deals with the Theory of Electrical Ignition of Gas.

On page 740 will be found an account of the Lighting of the New Building of the Institution of Electrical Engineers. The main feature is the system of indirect lighting in the lecture theatre by cornice lights, supplemented by mercury-vapour silica lamps which send their rays through a central glass area. The results of some tests on the illumination in various parts of the building are also given.

Following this will be found the second of the series of "Light Conversations in Illuminating Engineering" in which the lighting installation previously described is dealt with in a conversational and critical manner.

On page 746 will be found the usual Short Notes on Illuminating Engineering, including Correspondence and Publications Received, &c. A special feature in this number is also the series of Trade Notes relating to novelties in connexion with gas lighting.

At the end of the journal will be found the usual Review of the Technical Press.

TECHNICAL SECTION.

The Editor while not soliciting contributions, is willing to consider the publication of original articles submitted to him, or letters intended for inclusion in the correspondence columns of 'The Illuminating Engineer.'

The Editor does not necessarily identify himself with the opinions expressed by his contributors.

Co-operation on Lighting Problems.

A Message from Mr. S. E. Doane, Chief Engineer to the National Electric Lamp Association, U.S.A.

Among recent visitors from the United States interested in illumination, it was a pleasure to meet Mr. S. E. Doane, who attended the last meeting of the Illuminating Engineering Society in London on November 8th.

Mr. Doane has also kindly consented to depart from his usual practice by giving to readers the following message summarizing some of his impressions regarding the directions in which further progress in illuminating engineering in this country may now be expected to proceed :—

As a visitor in an unfamiliar country, I can naturally only express general views, but there are several features in the conditions here which strike me as distinct from those prevailing in the United States. Most of these can be traced back to the organized and concerted action between makers of lamps, galleries, and shades in that country. Our experience has been that it is absolutely essential, if the illuminating engineer is to do himself justice, that he should have a standard product to deal with.

Now in the United States reflectors, lamp holders, galleries, and lamps are so standardized that the illuminating engineer can now foretell results as regards intensity and distribution. Having decided on a given arrangement, he can leave the installation details in the hands of workmen possessing comparatively little knowledge of illuminating engineering principles, and yet feel confident that the final result will be what he anticipated.

It has been found to be very essential for example, that the filaments of lamps should always be in a certain fixed position relative to the reflectors, so that the resulting distribution of light can be accurately specified. In the same way, when a lamp has burnt out, and the consumer replaces it by another one, it is very desirable that the new lamp should exactly resemble that previously used, so that the distribution of illumination is unaltered.

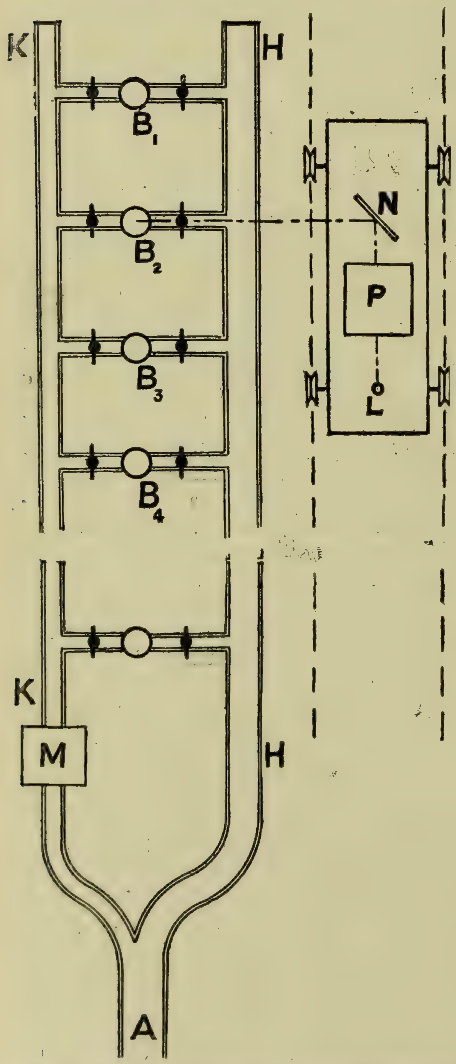
I believe, therefore, that concerted action in this direction will be found very beneficial by engineers in Great Britain, but it must arise through a spontaneous and general agreement regarding the obvious desirability of such standardization, and in prescribing the conditions, the advice of those intimately acquainted with the details of manufacture must be sought. It is also necessary to avoid over-specialization ; the main point is to bring about the *proper relation between the position of the filament and the reflector*, and this should be accomplished with as great a latitude as possible.

In conclusion, I should like to say that this is only one illustration of the need for co-operation between those concerned with different aspects of illumination ; it is to concerted action of this kind that the success of the Illuminating Engineering Society in the United States has been mainly due.

Note on the Rapid Photometrical Testing of a Number of Incandescent Gas Burners.

By P. Lauriol, Chief Engineer of the Lighting Department of the City of Paris.

In order to know the real value of a gas burner and mantle, it is necessary to run it for a considerable time, say 400 hours, test its candle-power every



100 hours, measuring simultaneously the output of gas. It is also desirable not to move the burner to and fro on the photometer bench, nor to extinguish it and relight it between each test.

We have found in our laboratory that the arrangement sketched in the accompanying illustration enables the work to be done quickly and correctly.

In the accompanying diagram, A is the main gas pipe branching into two, a large one, HH, and a small one, KK. The burners, B_1, B_2, &c., can be connected by means of the cross-pipes and cocks to either or both of these pipes, and also can be transferred from one pipe to the other without being extinguished. A check meter is placed at M. The photometer carriage, mounted on wheels to move rapidly from one burner to another, contains a photometer, P, a source of light, L, and a mirror, N. The type of photometer used is the Blondel-Broca, but any type in which neither the source of light nor the photometer itself have to be moved would be suitable. The light in this case is varied by the width of opening in the photometer. When a measurement is made we have :—

$$B_1 = a b_1 L$$

where B_1 and L are the candle-powers of the source of light tested and the comparison lamp respectively.

a is a constant depending on the distances B_1N, NP, LP, the nature of the photometer and the mirror.

b_1 is a number that may be calculated according to the variable width given to the photometer openings.

With the other burners we find :—

$$B_2 = a\, b_2\, L$$
$$B_3 = a\, b_3\, L, \ \&c.$$

With a standard lamp, S, in the same line as the burner, we have

$$S = a\, b_0\, L$$

Hence,

$$B_1 = \frac{b_1}{b_0} S \qquad B_2 = \frac{b_2}{b_0} S$$

Thus it is not necessary to know the value of either a or L, so long as they are kept constant; by this "double comparison" method, many sources of error are eliminated.

S, the candle-power of which must be known, is a standard electric lamp, which is only utilized for a very short time in each series of tests, and is frequently compared with other standards.

Screens are used to cut off light coming from other sources than those to be compared, but these are not shown in the diagram.

An Analysis of Illumination Requirements in Street Lighting.

By Arthur J. Sweet.

(Paper read before the Franklin Institute, Philadelphia, U.S.A., March 3rd, 1910; slightly abbreviated.)

(*Concluded from p. 654.*)

The Study of Glare Effect.

The second great division of our subject, the study of glare effect, has already been introduced in general terms in the earlier portion of this paper. It now remains to analyze glare effect closely, to determine the laws of operation of the conditions that produce it, and to learn the limitations which it imposes on our problem.

Subject to confirmation by research results, glare effect may be assumed to vary with the following factors:

(*a*) Distance of the eye from the light source.

(*b*) Total light flux in the direction of the eye, this being measured in apparent candle-power at the distance of the eye.

(*c*) Intrinsic brilliancy of the light source.

(*d*) Angular position of the light source in the field of vision, the visualiized object being assumed to occupy the centre of the field of vision.

(*e*) Distance of the light source from the eye relative to the distance of the visualized object upon which the eye is focussed.

In the research to be reported upon in the following paragraphs, the factor (*a*) was separately studied and determined with sufficient exactness to reliably indicate its character and approximate magnitude for distances up to 100 ft. Factors (*b*) and (*c*) were studied unseparated, as a single factor, the light flux varying directly as the intrinsic brilliancy. Factor (*d*) was separately studied and evaluated. Factor (*e*) was not investigated, the distance of the light source from the eye being in all cases taken as equal to the distance of the visualized object. This condition corresponds to the most usual condition of actual street vision.

Acuteness of Vision as a means of Testing Glare.

Heretofore no satisfactory measure of glare effect has been proposed. Since we are dealing with a psychological phenomenon, the basis of measure must obviously be a psychological one. On the other hand, the measure must be expressible in definite numerical units. A method of measurement based on visual acuity was ultimately adopted.

A careful preliminary investigation established the fact that, under widely varying daylight conditions, visual acuity was wholly independent of distance, within the limits investigated: that is to say, with any given type of visualized object, the minimum size of object which can be just barely distinguished as a separate unity is exactly proportional to the visual distance. Three different test plates, in which detail in gradually diminishing

size was displayed, were utilized, each object of unit gradation is 10 per cent. smaller than the one previous.

After establishing the fact just stated, each observer was calibrated, the determination being made of the minimum unit gradation which could be individualized under daylight conditions at various standard test distances. The fourth larger gradation was then chosen as the test object at the corresponding distance in the glare tests. This made it certain that the test objects were, by a uniform amount, well within the limits of visual acuity under any given condition. [The author believes that this basis of measurement is a very satisfactory one and has a wide field of usefulness in future investigations of this character.]

Connexion between Glare and Distance of Eye.

The basis of measurement being established, tests were first made to determine the relation between distance of the light source from the eye and the magnitude of the decrease in visual efficiency due to glare. These tests

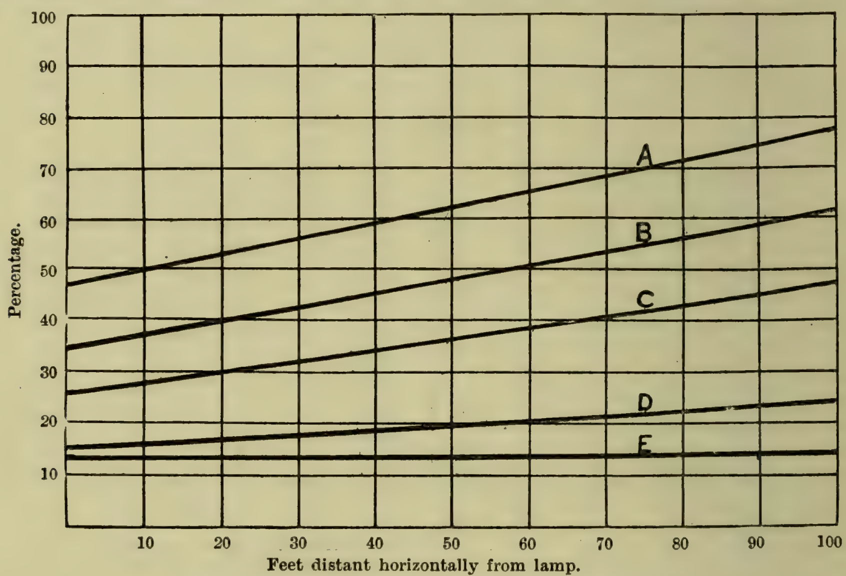


FIG. 8.—Relation between Glare Effect and Distance.
Curve A = 12·5 Candle power.
„ B = 50 „ „
„ C = 100 „ „
„ D = 200 „ „
„ E = 400 „ „

under adequate conditions of illumination. Consequently the ability to visualize these objects was wholly determined by the visual efficiency of the eye and by the intensity of illumination on the object. Expressed mathematically, we are here dealing with a constant which is a function of two variables. One variable, therefore, the minimum intensity of illumination on the object required to produce just-visibility, may be correctly employed as a measure of the other variable, the efficiency of the eye were made at five test stations, three independent sets of readings, one with each test plate, being taken at each station. Parallel tests were made with different observers. The complete series was then repeated with each observer, using various other candle-power intensities of the light source. The area of the light source throughout all these tests was kept constant, at about 50 square inches, the intrinsic brilliancy thus varying directly with the candle-power, as has already been stated.

Fig. 8 derived from the test data obtained as just described, expresses the relation between glare effect and distance, the light unit being situated beside the visualized object in the centre of the field of vision. The ordinates express visual efficiency in terms of the per cent intensity of illumination on the visualized object which would be required for equal visual acuity were the light source entirely removed from the field of vision. It will be noted that at 12½ c.-p. and an intrinsic brilliancy of 0.25 (British units), the glare effect drops off at a moderate rate with increase in distance. At higher candle-powers and higher intrinsic brilliancy, the glare effect decreases more slowly with increase in distance ; until finally, at 400 c.-p. and an intrinsic brilliancy of 8, there is no measurable decrease in glare effect with increase in distance within the limits investigated.

Connexion between Glare and Intensity.

Fig. 9, derived from the same test data, expresses the relation between glare effect and candle-power (or, as it may be instead, between glare effect and intrinsic brilliancy). These curves are especially significant. It will be seen that, for all ordinary distances, the presence of a light source of even a very low candle-power in the centre of the field of vision causes a tremendous drop in visual efficiency. It will also be noted that at 300 c.-p. the glare effect has nearly reached its maximum, and that beyond 300 c -p. a large increase in candle-power produces but a small decrease in visual efficiency. Finally one should not fail to observe that at any given candle-power a considerable increase in distance produces only a small decrease in glare effect.

Connexion between Glare and Angular Position.

The relation between glare effect and the angular position of the light source in the field of vision was determined by a series of tests similar in general method to the tests already described. The amount of illumination required to see the test object when the light source was in the angular position was compared with the amount required when the light source was in the centre of the field of vision. The results obtained are shown in Fig. 10. The ordinates here express the intensity of illumination required with the light source in the centre of the field of vision as measured in terms of the required intensity with the light source in the indicated angular position. This basis of plotting was chosen because of its convenience in enabling the curves of

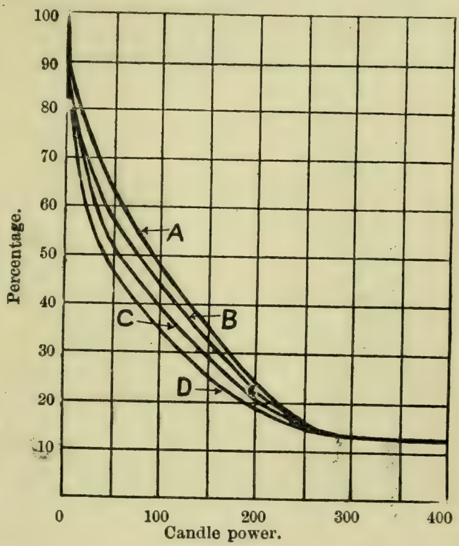


Fig. 9.
Relation between Glare Effect and Candle-Power.
Curve A = 100 feet.
" B = 80 feet.
" C = 60 feet.
" D = 40 feet.

Figs. 8 and 10 to be combined, thus giving the net glare effect for any desired angle and distance. The abscissæ in Fig. 10 represent the angles which the line from the light source to the eye makes with the line of vision.

The curves of Fig. 10 express a fact of the very highest importance in the study of glare, namely, that, at an angle varying, depending on the candle-power (intrinsic brilliancy ?), between approximately 22 degrees and approximately 26 degrees the glare effect reaches zero, although the light source is still well within the field of vision. This would seem to indicate that on its

physiological side, glare effect is a local retinal disturbance which, when sufficiently separated on the retina from the disturbance produced by the visualized object, does not extend to or affect the latter area of disturbance. This apparent fact seems to hold true even when a considerable time factor is introduced. Apparently pupillary contraction acts merely as a function protecting, within its very limited capacity, from a glare effect more or less suffused over the whole retina. The writer has previously believed that pupillary contraction was in itself a cause of decreased visual efficiency in that, on account of pupillary contraction, a lesser amount of light would be admitted to the retina from the visualized object. He now believes that pupillary contraction should be regarded as a purely protective function and not, through its operation, in any sense itself a cause of decreased visual efficiency.

Practical Avoidance of Glare.

The practical importance attaching to these facts is of no less vital interest than the scientific. Fig. 10 means that the light instrumental in causing glare comes entirely from the polar angles above 60 degrees. In the average actual case, glare is almost wholly caused by the light between the angles of 65 degrees and 80 degrees with the nadir. The light within these angles must be partially or wholly suppressed, as the further facts of the case shall show to be required, if glare is to be avoided.

Fig. 11, derived from Figs. 8 and 10, gives the curves of zero glare effect for various mounting heights. Comparing these curves with the curves of ideal distribution, we see at once that curves with a large value of M will be eliminated on account of the serious glare effect which would result from the application of such distributions to actual practice. The curve $M=4$, however, comes within the limitations imposed by the curve of zero glare effect, providing the scale of the $M=4$ curve does not exceed that amount which would make the zero-degree candle-power equal to 100 c.-p.

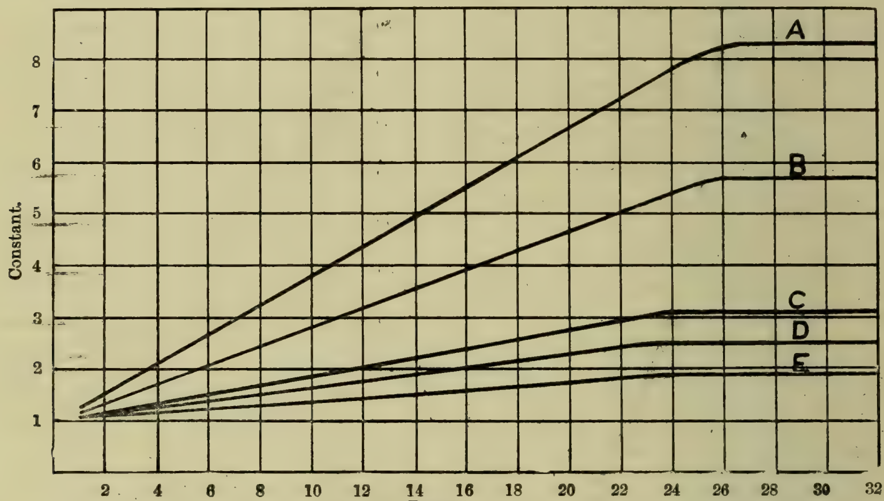


FIG. 10.—Relation between Glare Effect and Angular Position of Light Source.
Curve A = 400 Candle power.
„ B = 200 „ „
„ C = 100 „ „
„ D = 50 „ „
„ E = 12·5 „ „

Light must not Strike the Eye at Angles greater than 60° to Vertical.

Reference to Fig. 11 shows that for all practical purposes, 60 degrees is

an absolute limit for maximum candle-power if serious glare effect is to be avoided. It will also be observed that an increase in mounting height, while it does not change the limiting angle for maximum candle-power, does considerably lighten the severity of the limitations at 65 degrees and above. Mounting heights of the larger values, when made possible by actual conditions, are also desirable as permitting wider separation of units with resultant decreased installation and maintenance cost.

For mounting heights of 15 ft. or less, the curve $M=4$ will produce considerable glare, beyond, indeed, what proper limitations can permit. For such lesser mounting heights, as has already been pointed out, a closer spacing of units and a distribution corresponding to a curve $M=3$, should be used.

In designing a light unit to give the desired distribution which has the largest field of application, namely the distribution from $M=4$, it will be preferable by far that the candle-power values at 60 degrees and above, be less than those made proper by the ideal curve, rather than that these ideal values be exceeded. With an ideal curve of such candle-power magnitude as would be most useful, the candle-power values at the angles under consideration come perilously near to the glare limit, or may even exceed the glare limit. A per cent. variation from the ideal curve of four to one is, as has been pointed out (see page 651), permissible. Even a moderate condition of glare, on the other hand, is very undesirable. Practical considerations, therefore, will lead us, in the design of the actual unit, to intentionally deviate from the $M=4$ curve at the angles of 60 degrees and above, this deviation being in the direction of lesser candle power values.

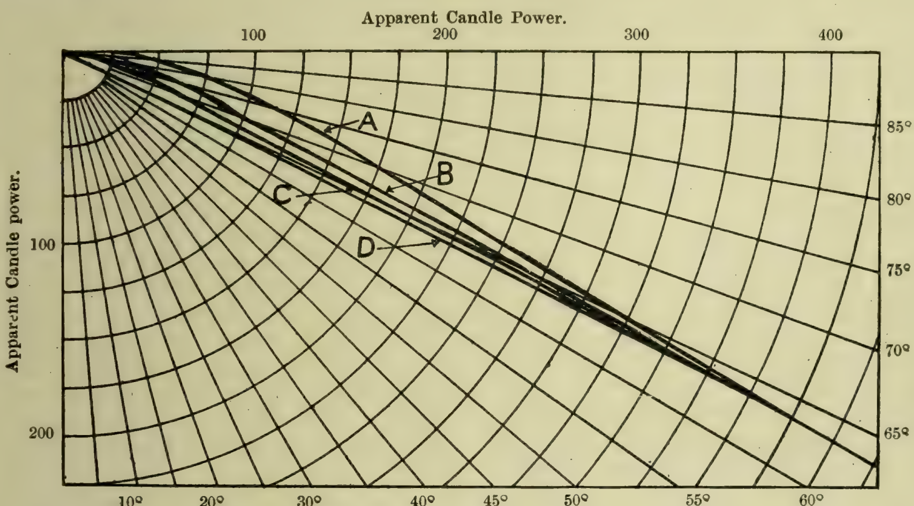


FIG. 11.—Curves of Zero Glare Effect for various mounting heights.

Curve A = 27 feet mounting height.
" B = 22 " " "
" C = 18 " " "
" D = 15 " " "

It is of the utmost importance to note that if the glare limit is exceeded at all, it will almost of necessity be exceeded excessively. The curve of zero glare-effect runs almost instantly back to zero near the angle of 65 degrees. The glare-effect would therefore increase with great rapidity as an angle of 65 degrees was exceeded, even in the case of a distribution whose curve approximated to one of the circular co-ordinates. The curves required for uniform illumination, on the other

hand, increase with great rapidity in candle-power values to their point of turning. It is obvious that the curve of zero glare-effect must be taken as a line of absolute prohibition. If it is to be exceeded at all, it may as well be entirely ignored. For an apparently small violation of the limit will produce a decrease in visual efficiency of approximately the same order of magnitude as the maximum possible effect.

It is also of great importance to note that the curve of ideal distribution for $M=4$, remains though not an ideal, yet none the less the best possible curve when applied to actual conditions where M has a larger value than 4. The curve $M=4$ gives the best spot-lighting effect and the best marker-effect which are possible without engendering a condition of glare. This research has indicated that, for ordinary mounting heights, moderate glare is a mere name: the reality is always excessive glare.

Conclusions.

It is the opinion of the writer, therefore, that glare must be avoided, even if so important a consideration as proper distribution has to be sacrificed. And indeed, as has been shown, other conditions than glare make a proper distribution impractical or even impossible with the larger values of M. The curve $M=4$ is to be regarded, therefore, not merely as the ideal curve for a certain relatively close spacing of light units which the public is not as yet educated up to, but as the best possible distribution which can be applied to any of our present-day spacings.

This paper is not presented, therefore, as merely expressing an ideal to be approximated to in a comparatively remote future. Rather, it should serve as a guide of immediate usefulness and application to present-day practice. And yet, as the writer is well aware, before such application has gained any great headway, there must be a vast amount of educational work accomplished. The ordinary citizen of to-day uses in his ignorance the very defect itself, the glaring character of a street illuminant, as a measure of its excellence. Such ordinary citizen would consider himself defrauded were he called upon to pay through his taxes for a street illumination characterized by absence of glare, by light on the street itself and not in the eye.

This paper, obviously, is not addressed to the ordinary tax-payer. It is addressed, through the medium of your honourable body, to the scientist, to the manufacturer of street illuminants, to the central station superintendent, to the educated and public-spirited citizen. Let these work shoulder to shoulder in the education of the public and this must eventually become a reality in a no distant future. And the rewards, whether commercial and material or as pride in a useful service accomplished, will come first and in largest measure to those of us who join in the work. So working shoulder to shoulder, let us teach the public, teach them so thoroughly that it becomes a popular catch-word "Light on the object, not in the eye." Let us teach them that this "light on the object," can be accomplished only by a closer spacing of light units, which will mean a larger increase in installation cost, though but a small increase in operating cost: that light "not in the eye" means of necessity absence of glare; so that the excellence of a street illumination must be measured by absence of glare, rather than by the presence of glare. Thus working together, in our own time shall come the day when our streets are illuminated by night as beautifully, and with as great comfort to the eye, as the open country road lying clear in the bright moonlight.

TRANSACTIONS

OF

The Illuminating Engineering Society

(Founded in London, 1909.)

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

Recent Progress in, and the Present Status of Gas Lighting.

(Proceedings at a Meeting of the Illuminating Engineering Society held in the House of the Royal Society of Arts (London), on Tuesday, November 8th, 1910).

THE opening meeting of the second session of the Illuminating Engineering Society was held at the House of the Royal Society of Arts, on Tuesday, November 8th, the chair being taken by the **President, Prof. S. P. Thompson,** D.Sc., F.R.S., who, it will be recalled, at the earnest desire of the Council of the Society had kindly consented, at the Annual General Meeting, to continue in office for a second year.

There was an excellent attendance, many prominent members of the gas industry being present, and participating in the proceedings.

The minutes of the Annual General Meeting having been taken as read, the **President** remarked that, this being the opening meeting of the second session, it had been thought well to begin right off with the ordinary business of the Society. Last year generalities were dealt with, but it was hoped during the present session to be a little more specific, and to devote particular evenings to special subjects. They were fortunate in being able to open the session with a paper by Mr. Goodenough which would introduce questions that were of burning interest in the most literal sense of the word, in the gas industry. At other meetings they would discuss the equally burning questions that were agitating the minds of electrical engineers, and would deal with other parts of the subject of illumination. The Council had arranged for a discussion on the lighting of libraries, and it was intended to follow that up with meetings devoted to other particular branches of lighting. As far as the Council could see, everything tended to the session being as active and as interesting as the previous initial one.

The **President** then proceeded to explain that during the Vacation the Hon. Secretary had been acting as the representative of the Society, and, among other matters, he and Mr. J. Eck had been present as official delegates of the Society at a very important congress held in Brussels.

He now proposed, therefore, to ask Mr. Gaster to present a brief report of what the Society had been doing in the person of its representative since the last meeting.

The **Hon. Secretary** said that the congress referred to by the President was the SECOND INTERNATIONAL CONGRESS ON INDUSTRIAL HYGIENE held in Brussels under the auspices of the Belgian Government during September of this year.* This was the first time that the subject of illumination in its hygienic aspect had ever been considered by a congress of this nature. There were over 600 delegates, most of them being official representatives of different Governments, and he was glad to say that the Home Office and British authorities had been very well represented. Over 110 papers were read, of which more than 20 per cent emanated from this country. The

* *Illum. Eng.*, Lond., October, 1910, p. 599.

Society having been invited to be officially represented, four delegates were appointed, viz., the President, Mr. Eck, Mr. Wallis-Jones, and himself. Unfortunately the President and Mr. Wallis-Jones were unable to attend, but Mr. Eck and himself were present. The importance of good illumination for industrial processes had been thoroughly appreciated and he had had the privilege of reading a paper on the hygienic aspects of lighting which set forth the aims of the Society in this direction; this would be published in the Transactions of the Congress.

The various delegates, while not seeing their way to recommend immediate legislation, had all agreed that illumination ought to be regarded in the future as an essential feature of the matters deserving the attention of Governmental authorities, just as ventilation and the provision of good air in factories were now recognized to be. It was also agreed that in order to avoid accidents as far as possible, the conditions of illumination requisite for the safeguarding of dangerous machinery should be investigated and defined. This was the spirit in which illumination was discussed at the Congress, and it was gratifying to find that in future it would be dealt with again and that information would be accumulated with a view to ultimate international action.

The **President**, after thanking the **Hon. Secretary** for his report, called upon him to read the names of those proposed for membership, and also of applicants who would now be formally declared Members of the Society. (A list of these names will be found on the opposite page).

The **Hon. Secretary** in doing so, alluded to the fact that his visit to Brussels had been instrumental in inducing **Dr. Moeller**, the distinguished President of the Congress mentioned, to consent to become one of the Honorary Members of the Society for the next session—a gratifying recognition of the status of the Society. He was also pleased to announce that **Prof. J. P. Langlois** and **Dr. L. Carozzi**, who took a prominent part in the proceedings at the Congress, and also **Dr. A. Broca**, had promised to become corresponding members and that **Prof. W. E. Wedding**, the well-known authority of lighting in Berlin, had accepted to act as a Vice-President.

The President then called upon **Mr. F. W. Goodenough** to read a paper on RECENT ADVANCES IN, AND THE PRESENT STATUS OF GAS LIGHTING, and an interesting discussion followed in which **Mr. C. Carpenter, Mr. C. W. Hastings, Mr. W. H. Y. Webber, Dr. R. Lessing, Mr. W. J. A. Butterfield, Mr. S. E. Doane** (who referred to the good work done by the Illuminating Engineering Society in the United States, and expressed his good wishes for the prosperity of the sister society in Great Britain), **Mr. S. E. Thornton, Mr. A. E. Broadberry, Mr. R. W. Edwards** and **Mr. J. H. A. Baugh** took part.

Mr. Goodenough replied and the **President** subsequently called upon the meeting to accord him a very hearty vote of thanks for his paper, which was given with acclamation. This paper, and the discussion which followed will be found *in extenso* on pages 715-731.

Subsequently the President mentioned that a series of queries relating to recent advances in gas lighting had been prepared by the Hon. Secretary, and submitted to various authorities, communications from two of whom, **Mr. Geo. Keith** and **Mons. P. Lauriol** (Paris) had already been received. These two contributions were dealt with in abstract by the President, and are reproduced, with other contributions since received, on pages 733-738.

In conclusion the President announced that the **next meeting** of the Society would take place in the same room on **Friday, December 9th**, when a paper entitled RECENT PROGRESS IN ELECTRIC LIGHTING would be delivered by **Prof. E. W. Marchant**.

The meeting then terminated, and most of those present adjourned to the library where tea and coffee were provided.

ELECTION OF NEW MEMBERS OF THE SOCIETY.

At the meeting of the Illuminating Engineering Society, held at the house of the Royal Society of Arts on November 8th, 1910, the names of the following applicants for membership, as read out at the previous meeting on May 23rd, were formally approved, and these gentlemen were declared Members of the Illuminating Engineering Society :—

Bond, C. O.	Manager of the United Gas Improvement Co., Photometrical Laboratory, Philadelphia, U.S.A.
Richtmyer, Prof. F. K.	Instructor of Physics, Cornell University, 108, Linden Avenue, Ithaca, N.Y., U.S.A.
Thornton, S. E. *A.M.I.C.E.*	Chairman of Messrs. W. Sugg & Co., Sanctuary House, Tothill Street, London, S.W.
Weekes, R. W. *M.I.E.E.*	Consulting Engineer, Maxwell House, Arundel Street, Strand, London, W.C.

Corresponding Member :—

Besso, A.	Consulting Elec. Engineer, 15, Schwarzenburgstrasse, Bern, Switzerland.

NEW APPLICANTS FOR MEMBERSHIP.

In addition the names of the following gentlemen have been duly submitted and approved by the Council, and were read out by the Hon. Secretary at the meeting of the Society on November 8th :—

Honorary Member :—

Dr. A. Moeller	President of the Academie Royale de Médicine, Member of the Commission des Accidents du Travail, President of the Congrès International des Maladies Professonelles, Brussels, 1910, 1, Rue Montoyer, Brussels.

Vice-President :—

Prof. Dr. W. Wedding	Professor at the Technische Hochschule Charlottenburg, Gross Lichterfelde, Wilhelmstrasse 2, Berlin.

Corresponding Members :—

Böhm, Dr. R. C.	12, Meinekestrasse, Berlin W. 15.
Broca, Dr. A.	Agrégé de la Faculté de Médicine, 7, cité Vaneau, Paris.
Carozzi, Dr. L.	Doctor of Medicine at the Instituti Clinici di Perfezionamento, Corso San Celso, 6, Milan.
Langlois, Prof. J. P.	Professeur Agrégé à la Faculté de Médicine, 155, Boulevard St. Germain, Paris.

Members :—

Chapman, W. P.	Lighting Expert and Salesman to the Holophane Co., 36, West 39th Street, New York.
Coote, E.	Manager, Lamp Sales Dept., British Thomson-Houston Co., 83, Cannon Street, London, E.C.
Cunnington, A.	13, The Chase, Clapham Common, London, S.W.
Doane, S. E.	Electrical Engineer of the National Electric Lamp Association, Ohio, U.S.A.
Gutmann, W.	Lighting Contractor, 109, Finchley Road, London, N.W.
Hawkins, F. J.	Lamp Dept., British Thomson-Houston Co., Rugby.
Higgins, G.	East Rand Proprietary Mines, Johannesburg.
Howe, Prof. G. W. O.	Asst. Prof. of Electrical Engineering at the Central Technical College, Exhibition Road, South Kensington, London, S.W.
Howell, J.	Chief Engineer, Lamp Dept., British Thomson-Houston Co., Rugby.
Hunter, W. G.	Lamp Works, British Thomson-Houston Co., Rugby.
Mather, Prof. T. *F.R.S.*	Prof. of Electrical Engineering at the Central Technical College, Exhibition Road, South Kensington, London, S.W.

Reiter, Dr. C.	Chief Chemist of the Imperial Lamp Works, 17, Osborne Road, Brimsdown, MIDDLESEX.
Sparborg, H. N.	Chief Engineer, British Thomson-Houston Co., RUGBY.
Watkins, S. S. A.	Demonstrator in Optics and Electrical Engineering at the Central Technical College, Exhibition Road, LONDON, S.W.
Willcox, F. W.	Inct. Lamp, Sales Dept., General Electric Co., HARRISON, N.J., U.S.A.
Wilson, D. R.	H.M. Inspector of Factories, Home Office, Whitehall, LONDON, S.W.

CHANGES OF ADDRESS, &c.

	Barkham, H. C.	Electrical Engineer, The Gables, Jaffray Road, Erdington, BIRMINGHAM.
	Beeton, H. R.	Chairman of the Brompton Electricity Co., 254, Earl's Court Road, S.W.
	Beutell, A. W. *A.M.I.E.E.*	Electrical Engineer, 2, Voss Court, Streatham Common South, LONDON, S.W.
	Briggs, A. S.	Assistant in the Gilbert Arc Lamp Co., Chingford, 27, Bedford Road, Walthamstow.
M.C.	Cox, F. J. *M.I.M.E.*	Consulting Engineer to the Machine Gas, Ltd., Welsbach House, Gray's Inn Road, LONDON, W.C.
M.C.	Herring, W. R. *M.I.C.E.*	Palace Chambers, Bridge Street, Westminster, LONDON, S.W.
C.M.	Lauriol, P.	Chief Engineer of the Lighting Department of the City of Paris, 37, Avenue Elisée Reclus, Paris.
M.C.	Parsons, Dr. J. H. *F.R.C.S.*	Ophthalmic Surgeon, Lecturer at University College, &c., 54, Queen Anne's Street, Cavendish Square, LONDON, W.
	Reiner, J. B.	Optician, 2, Vere Street, Cavendish Square, London, W.
	Solomon, M. *A.M.I.E.E.*	Manager of the General Electric Co., Carbon Works, Witton, Birmingham, Bradley, Grange Lane, Erdington, Birmingham.
	Strangways, G.	46, Woodland Gardens, Muswell Hill, LONDON, N.
	Thomson, T. G.	57, Haselrigge Road, Clapham, LONDON, S.W.
	Thornton, S. E.	Chairman of Messrs. W. Sugg & Co., Sanctuary House, Tothill Street, Westminster, LONDON, S.W.

Official Notice of the Next Meeting.

The next meeting of the Illuminating Engineering Society will be held at the House of the Royal Society of Arts (John Street, Adelphi, London, W.) on **December 9th, 1910**, at **8 p.m.**, when a paper entitled '**Recent Progress in Electric Lighting**' will be delivered by **Prof. E. W. Marchant, D.Sc.**

The **President, Prof. S. P. Thompson, D.Sc., F.R.S.** will be in the Chair.

Recent Progress in, and the Present Status of Gas Lighting.

BY F. W. GOODENOUGH, Mem. Inst. Gas Engineers.

(Paper read at a meeting of the Illuminating Engineering Society, [Founded in London, 1909], held at the House of the Royal Society of Arts, John Street, Adelphi, London, on Tuesday, November 8th, 1910, at 8 P.M.).

THE object of this paper, as I understand it, is to put before those responsible for, or interested in the illumination of premises or thoroughfares information respecting recent developments and the present possibilities of gas lighting, so that, should that illuminant be selected for any installation, the greatest efficiency may be secured and maintained at the least cost.

This is not the occasion, nor is the platform of this Society the place, for any discussion of the relative costs or merits of rival illuminants. That is a battle which must be, as it is being, fought out in the less peaceful atmosphere of the commercial world; and, whilst not averse from taking a modest share in the combat when occasion serves, I hope that I shall now and at all times succeed in keeping anything I may say at a meeting of this Society—which stands or falls by its power to avoid commercial as opposed to scientific controversies—free from offence to my good friends who are interested in other illuminants. It appears to me to be one, and not the least, of the advantages of this Society that it forms a meeting-place where those who in commercial life are combatants can meet together for the interchange of ideas upon subjects of common interest, and discover perhaps that the others are not such terrible fellows after all.

It is, I think, a matter of congratulation that in this country the great majority of those who most strenuously oppose one another in business or in politics have the gift of maintaining personal friendships in private life or on neutral ground. Long may this Society be a standing evidence to that effect. The preparation of this paper has presented more than one difficulty, as not only was it essential that its matter should not verge upon the commercially contentious as between rival illuminants, but it was also, I felt, essential that it should not become the vehicle for the advertisement of any particular make or makes of lamps or burners or mantles to the disadvantage of others.

This Society, being one for the discussion of general principles governing the use and application of illuminants, cannot concern itself with, or allow itself to be exploited in the interests of, manufacturers competing with each other for the favour of illuminating engineers and their clients.

For that reason, which will I am confident commend itself to the members as a whole, I came reluctantly to the conclusion that it was only possible to deal with my subject on the most general lines; and that it was impossible to have the paper illustrated by samples of various lamps, burners, &c., unless a large building was secured and a general and open exhibition of gas appliances were arranged. Even then the exhibition could have little value for illuminating engineers, unless every exhibit could be submitted to an impartial committee of experts to test and adjudicate upon the claims of efficiency made on their behalf. If that were possible, it would be very valuable indeed to all parties, but it is a proposition of no little magnitude and out of the question at the present moment.

I offer this explanation as an apology in advance for the meagreness, and I

am afraid the very dull and uninteresting character, of my paper, which is confined strictly to general terms.

A consideration of the recent history

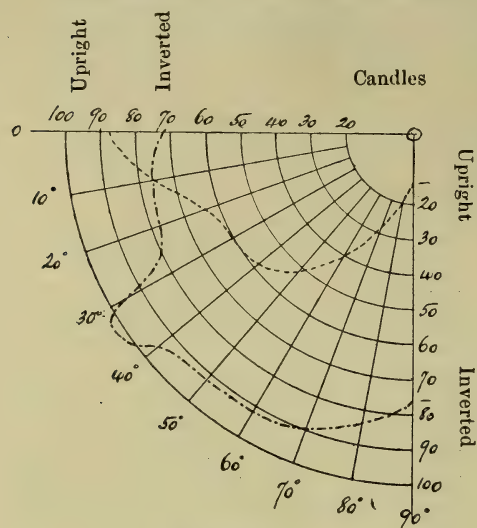


DIAGRAM I.

Characteristic Curves of Upright and Inverted Low-Pressure Gas Burners.

and the present position of the science of lighting by coal gas necessarily centres itself upon the inverted incandescent burner; whether one is con-

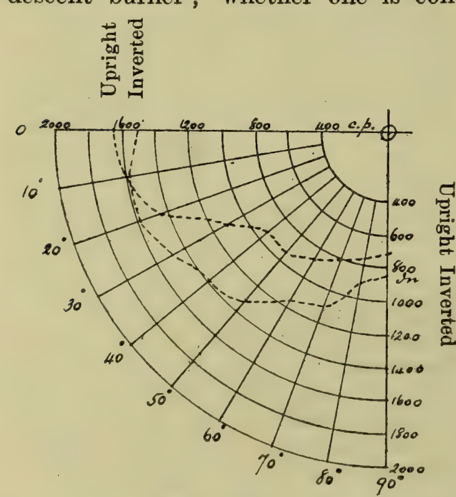


DIAGRAM II.

Characteristic Curves of Upright and Inverted High-Pressure Gas Burners.

sidering the utilization of gas at the ordinary district pressure of, say, 3 in. head of water, or the use of gas under special pressure of, say, 6 in. head of mercury, which is becoming very general, especially of late, for the exterior lighting of rows of shops. In such cases the gas at increased pressure is supplied from a common centre and charged for on the basis of estimated consumption for a predetermined number of hours per annum (arrived at from an agreed time-table for lighting and extinguishing) plus maintenance charges and working costs. This co-operative system of lighting has been widely adopted in the United States,

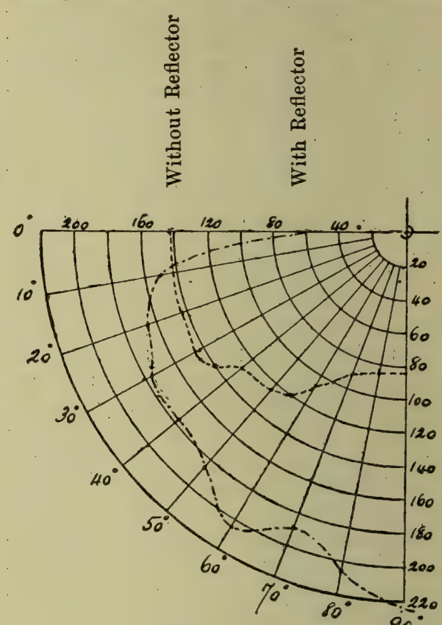


DIAGRAM III.

Alteration to Curve obtained from an Inverted Burner by fitting a Reflector to Concentrate Light on Office Desks.

and there is undoubtedly a large opening for it in this country. It will certainly improve the appearance of the streets in which it is adopted, as the striking lack of uniformity in—the enormous difference between — the power and character of the lights employed by the various shops in our streets at the present time detracts very largely from the general effect. A street lighted brilliantly throughout on a definite plan by the shopkeepers would, I believe, be very attractive to those whom shopkeepers desire to attract.

It is of interest to note that the inversion of the burner has been the means of increasing the light obtained per cubic foot of consumption in both of the two distinct eras of gas lighting—the era of the directly-luminous and that of the Bunsen, or indirectly-luminous, burner. The inverted burner of the Siemens or Wenham type increased the efficiency of the luminous burner nearly three-fold, namely, from $2\frac{1}{2}$ c.-p. per cubic foot in the ordinary batswing burner, or $3\frac{1}{4}$ c.-p. per cubic foot in the Argand burner, to 8 or 9 c.-p. per cubic foot in the Wenham lamp. The result was, of course, due to the heating of the gas and air prior to combustion.

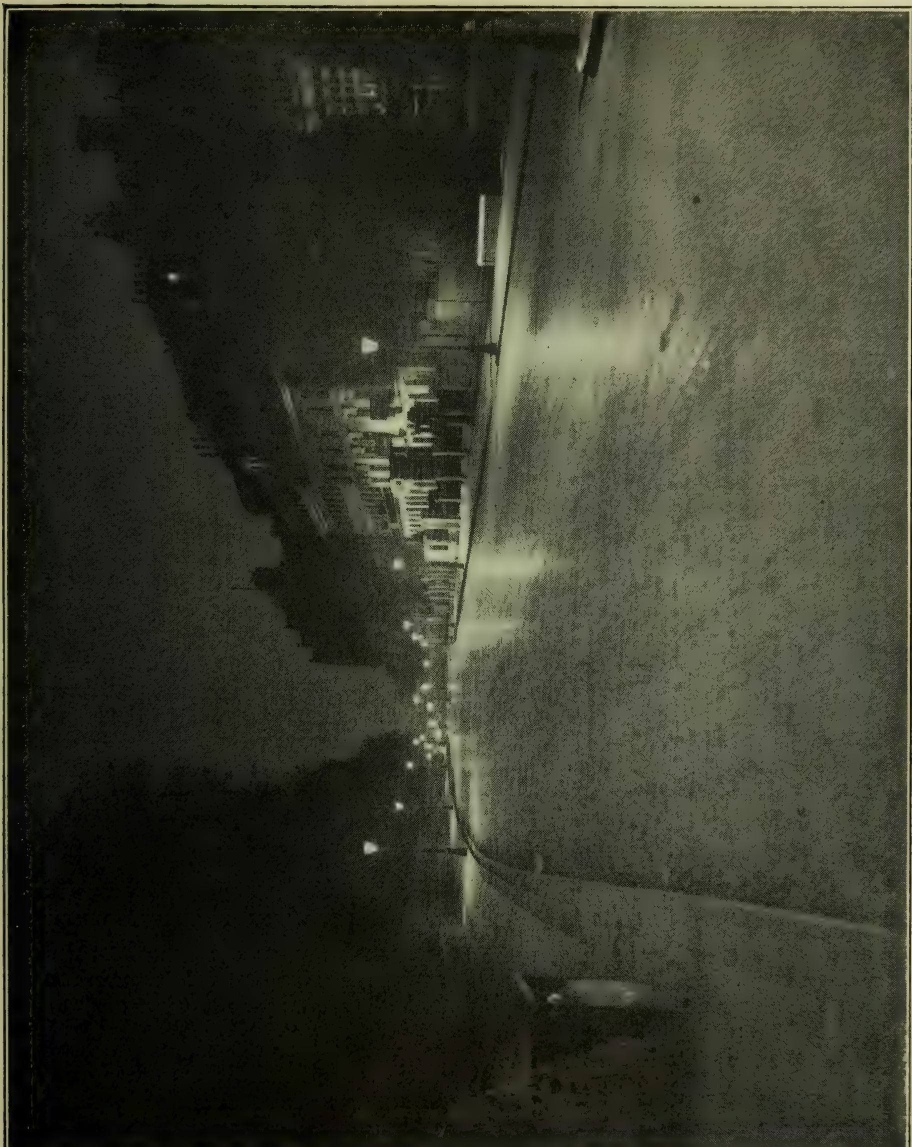


FIG. 1.—Kensington Road. Photograph taken by light of low-pressure inverted gas burners.

Welsbach's great discovery of the incandescent mantle, with its ultimate

efficiency in the supported—or, as it is generally called, the upright—form of from 20 to 40 c.-p. per cubic foot, according to the pressure used, necessarily eclipsed the inverted luminous burner; but history has repeated itself in this case; the inversion of the burner has brought about a materially increased efficiency, and the inverted mantle has now eclipsed the fork-supported type. This is due not only to the higher efficiency of the former, but also (1) to its lending itself to the use of shadowless lamps; (2) to its capability of being used in considerably smaller units of light (from 25 c.-p. upwards instead of a minimum of 50 c.-p.); (3) to its consequently lending itself more readily to artistic effect in illumination; and (4) to its

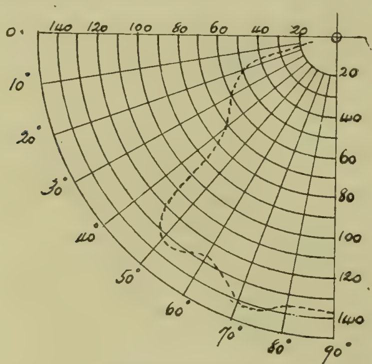


DIAGRAM IV.

Curve obtained by Use of Pyramid Reflector with Inverted Burner for giving an Intensified Light on Drawing Table.

further capability of being used in larger units of light, any power up to 4,000 c.-p. in one lamp being obtainable.

The latest pattern inverted burners supplied with gas at the ordinary district pressure of 3 in. (water gauge) give an efficiency of 30 c.-p. per cubic foot consumed; whilst used with a pressure of about 90 in. water gauge (equal to about $6\frac{1}{2}$ in. mercury gauge) the inverted burner gives an efficiency of 70 c.-p. per cubic foot consumed.

These higher efficiencies are due to a higher flame temperature being obtained by the pre-heating of the gas and air, which after admixture descend to the point of ignition through a tube surrounded by the ascending products of combustion.

The figures given are maximum candle-powers averaged between the angles of 10° to 40° below the horizontal, that being, in my view, the direction in which it is desirable that maximum illumination should be available to ensure as even a diffusion of light as possible.

With the light emanating from a source of the shape of an inverted mantle, which gives direct rays in every direction except immediately upwards, and which is not obscured in any direction below the horizontal, adequate light is always assured in the immediate vicinity of the burner; and the greater the distance the light has to travel to reach the object to be illuminated, the greater, also, the initial power of the far-travelling rays must be in order to produce illumination approaching in efficacy to the illumination of objects more nearly under the source of light. It is of importance to the illuminating engineer that the burner he uses should be capable of doing its best work in the direction in which most light is wanted.

At the same time, the light in other useful directions must be proportionately adequate, and that is a valuable characteristic of the inverted mantle. This is illustrated by diagrams I. and II., showing the characteristic lighting curves obtained from inverted burners of both ordinary and high-pressure types, compared with those obtained from burners of the upright pattern.

Where greater concentration of light in any particular direction is essential for specific purposes—as, for example, for the lighting of shop windows from without, or of drawing-boards, machines, compositors' frames, and the like, from above—this can, of course, readily be obtained by means of suitable reflectors; and here again the inverted burner possesses advantages over the older type owing to there being no obstruction whatever of the downward rays. The effect of imposing suitable reflectors for downward lighting is illustrated by diagrams III. and IV.

The advantage of the light from an inverted burner being entirely free from

obstruction below the horizontal enables it to be used effectively for street lighting, not only in the column-supported lamp, but also in suspended lamps, whether from brackets as in Fleet Street (high-pressure) and the eastern end of Cheapside (low-pressure) or centrally hung from cross wires as in the eastern end of Cannon Street.

The central hanging of gas lamps from cross wires, the gas being conveyed to the lamps either by flexible metallic tubing or barrel with flexible joints—enabling the lamps to be drawn to the side of the street and lowered for purposes of maintenance—is one of the latest adaptations of gas lighting in this country, though it has been adopted in several towns in Germany for some time past. The trial installation of this

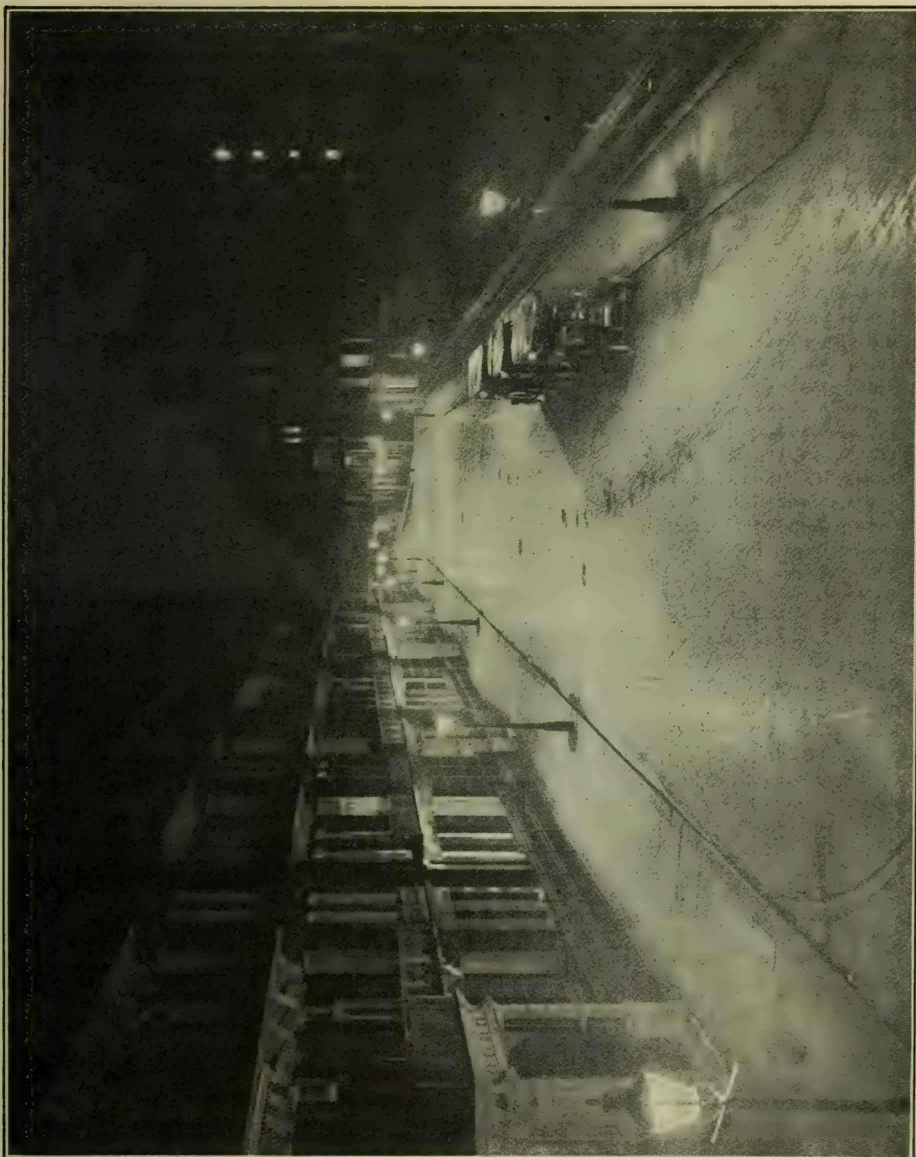


FIG. 2.—Ashley Gardens. Photograph taken by light of low-pressure inverted gas burners.

system in the eastern end of Cannon Street (which is only just in course of completion) will, therefore, be of interest to those who favour the system of lighting streets by cross-suspended lamps—which I personally, as an illuminating engineer, regard as radically unsound, and, as a humble citizen, consider an unnecessary aggravation of the already too frequent disfigurement by overhead wires of the at all times too restricted amount of sky vouchsafed to our town-tired eyes.

The application of the inverted burner to the more usual method of street lighting, namely, by column-supported lamps, has recently been illustrated on a considerable scale by the substitution of inverted burner lamps, both low and high-pressure, for the older pattern gas lamps in portions of the City of Westminster. Good examples of the latest high-pressure inverted gas lamps will be found in Victoria Street—one being conveniently placed opposite the offices of this Society—and in Parliament Square and Whitehall; whilst as good specimens of street lighting by low-pressure inverted lamps I might mention Great George Street, Ashley Gardens, Vauxhall Bridge Road, Kensington Road from Knightsbridge to Queen's Gate, Prince Consort Road, St. James's Square, and Carlton House Terrace.

Some photographs, taken at night by the light of the lamps, which I have had reproduced, illustrate as well as such photographs can the even diffusion of light obtained. This is due mainly to the fact that the rays of highest power are those at an angle of from 10° to 40° below the horizontal, but partly also to the fact that the shortness of the mantles, and the height (and distance apart) at which the mantles are placed in the lamps, ensure that one mantle does not obscure the light of another in any useful direction.

It may be observed on the subject of street lighting that it is a matter of congratulation to the honest and respectable wayfarer by night that our local authorities are becoming more and more alive to the imperative need for a higher standard of efficiency in street lighting in the Metropolis, which has arisen out of the rapid and ever increasing growth of fast motor traffic in the streets. A standard of illumination that was adequate in the days of horse-drawn cabs and carriages has been rendered insufficient by the multitude of swiftly-driven "taxis" and private cars that now whirl along our streets at night, and which must be made clearly visible at a distance to the pedestrian if the crossing of a street is not to become a matter not only of anxiety, but of serious peril. Illuminating engineers who have influence with local authorities may do good service to their fellow-citizens by laying stress upon this point.

A further point of interest to mention in connexion with recent developments in gas lighting for streets is the extending use of automatic appliances for the lighting and extinguishing of street lamps.

Many ingenious forms of apparatus for this purpose have been perfected and put into practical use in recent years. The first to be mentioned are those which work by means of a clock-actuated mechanism. These are not suited to districts where the irregular lighting of the lamps is from time to time necessitated by the sudden advent of fog, for which purpose the necessary staff no longer exists if clock-work lighters have been installed. This is a point that needs to be borne in mind by any Metropolitan authority which is considering the adoption of automatic appliances for street lamp lighting.

This objection does not apply to the other class of automatic apparatus namely, that which is operated by an increase of gas pressure at the lamp, which can be given from the works when required, either for lighting or extinguishing.

There are several forms of these pressure-operated apparatus, some of which are best suited to districts having a simple system of distribution from a single works, but which do not, as other appliances do, meet the peculiar conditions of undertakings having a complex system of distribution from a number of works supplying a common network of mains. The latest form

that is being tried in London has the peculiarity of being affected by sudden slight rises in pressure deliberately applied without being operated by gradual increases such as occasionally register line to a constant reading than in former years is one of the modern developments of gas supply.

Automatic methods of lighting and extinguishing can also be readily applied

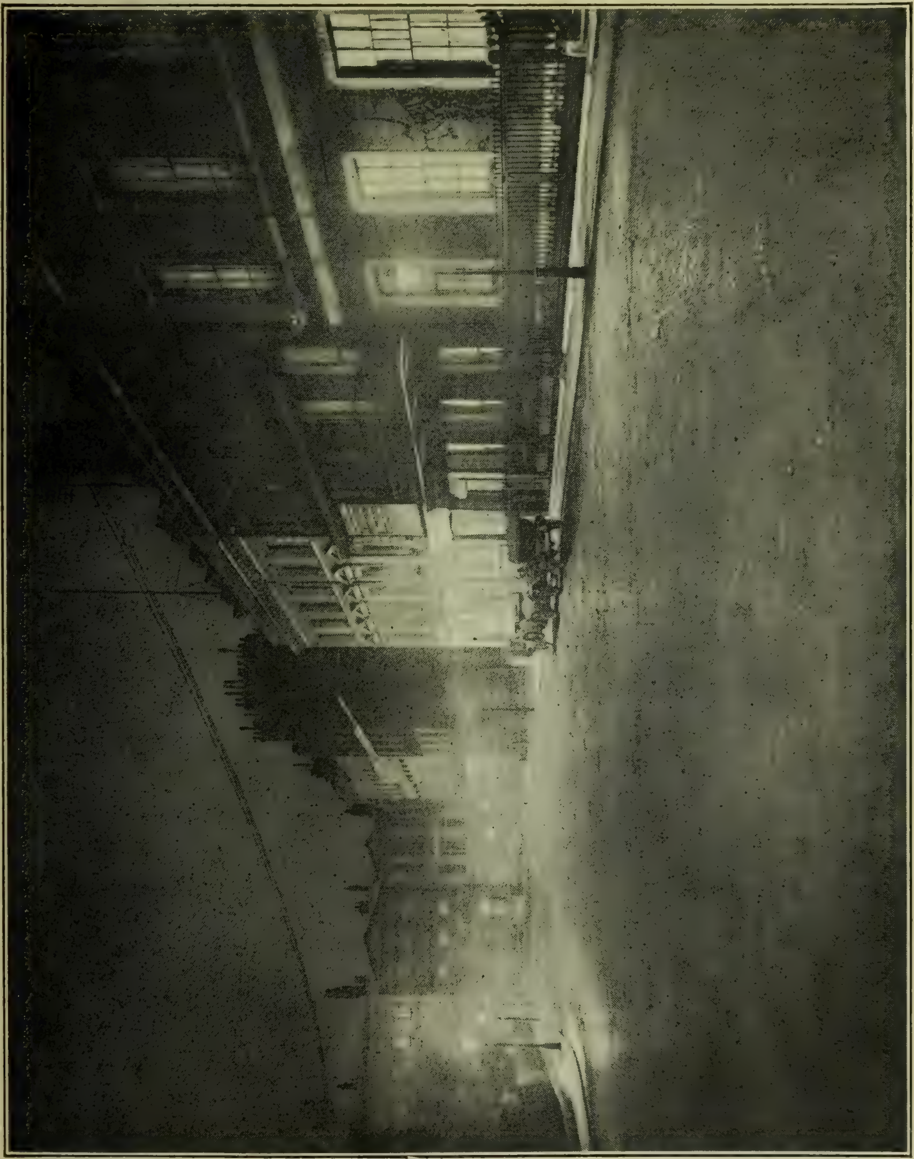


FIG. 3.—St. James's Square. Photograph taken by light of low-pressure inverted gas burners.

take place after lighting-up time, due to variations in load on mains that are worked to their full capacity. It may be remarked in passing that a much closer approximation of the pressure- in the case of both low and high-pressure gas supplies where all the lamps to be lighted are on a common service. This, of course, applies either to street or internal lighting.

In the case of high-pressure installations, the act of starting the compressor will light up all the lamps supplied from it by the higher pressure opening valves which remain closed at ordinary pressures ; and this system is widely adopted. At the Victoria Station of the Brighton Railway the platform lamps are controlled in alternate series by cocks at the platform ends, so that the lighting of the platforms can be increased, diminished, or extinguished altogether from one point.

Pneumatically operated valves on single burners to enable small units of light to be lighted with the aid of a bye-pass from a distant point have been widely adopted in recent years for both domestic and other indoor lighting; whilst electrically operated appliances which light as well as turn on the gas are also coming into use.

A further advantage attaching to the inverted burner is that the life of the suspended mantle is distinctly longer than in the case of the supported mantle, chiefly by reason of its more compact form.

This leads to the consideration of a point of great importance to the illuminating engineer, and that is the question of the maintenance of the mantles in an installation of gas burners. In this respect the gas industry has made substantial progress in recent years, both in regard to the quality of the mantles obtainable—I use the word advisedly, as distinct from obtained—and with respect to the facilities offered by gas undertakings to consumers for the periodical inspection and cleaning of their burners and the renewal of mantles when necessary, at a fixed annual or quarterly charge.

This periodical attention to incandescent burners by competent men is commended to illuminating engineers and their clients on several grounds.

First and foremost of these is that a gas company is in a position to ensure that no mantles shall be used other than the best obtainable. The low-priced, but dear, because unsatisfactory, mantle is as great an enemy to the gas industry as the low-priced but also low efficiency and short-lived lamp is to the electrical industry, and it is the business of all concerned in either industry to do everything possible to eliminate the undesirable.

A gas company can and should, as many do, submit samples of the mantles sold to them to a continuous and severe test, and ruthlessly reject the bulk when the samples fall below the highest standard. The Gas Light and Coke Company take hap-hazard samples out of stock every week and submit them to photometric tests (continued at intervals over a period), and also to shock-resisting tests on a machine devised for that purpose by Messrs. Woodall & Moon. They do not issue any specification for the supply of mantles, it being a matter for competition amongst the manufacturers to produce the highest combination of efficiency and durability, and those who succeed secure the business, and retain it so long as they keep up to the standard they have set, and no longer.

The result is, therefore, that the consumer who places his lights under a maintenance contract with the Company ensures that the mantles used will give him the best light obtainable for the gas consumed.

A further result is that the burners will be freed from the inevitable accumulations of dust from the atmosphere ; the glassware will be thoroughly cleaned and its transparency maintained ; and new mantles will be supplied—all at sufficiently frequent intervals to ensure the maintenance of a constantly good light.

Where there is no system of regular periodical over-hauling by men trained in the work, but the putting of a light into order is only done when the patience of the individual using it has become exhausted and his dissatisfaction has reached the stage of audible and violent expression ; and where the maintenance work is done by that class of person usually described as a "handy man," for the reason, apparently, that he is never at hand when wanted and is handy at anything but the job entrusted to him—in these cases, and they are still too frequent, the consumer deprives himself of a percentage of the light obtainable from the illuminant purchased

and "economises"—if he does "economise"—at his own expense.

Another advantage incidental to a maintenance contract is the fact that the consumer can estimate beforehand, or find out at any time, with certainty, his cost for up-keep, which otherwise, except in business houses where costs are carefully kept and closely analyzed, is a matter of doubt and consequently of uneasiness to the consumer.

A further advantage of the contract system is that both the consumer and the supplier know whom to blame and censure if the lighting of premises open to the public view is unsatisfactory. It is very irritating to the supplier of any illuminant to see his commodity laid open to adverse

FIG. 4.—Victoria Street. Photograph taken by light of high-pressure inverted gas burners (Street wet from scavenging).

criticism through its mis-use by the buyer, and to be impotent to effect an improvement because the consumer is satisfied to let things remain as they are.

I am confident that no supplier of illuminant can afford, nor ought he to be content, simply to supply the commodity and leave the consumer to work his will with it, unadvised or unassisted; and I feel that illuminating engineers can do good service both to the users and the suppliers of illuminants by advising their clients to entrust the upkeep of their installations to those who have the next greatest interest in their efficient maintenance.

I have spoken of new mantles being supplied at sufficiently frequent intervals to ensure the maintenance of a constantly good light. The question may be asked: What should be the frequency of those intervals, and how is one to determine when a mantle requires renewal because of loss of power as distinct from obvious damage?

This is a question the answer to which cannot be precise, because everything depends upon the local conditions under which the mantle is used. It may, however, be stated as a general proposition, founded upon a large series of tests, that if the burner receives such periodical attention as it would from an ordinary qualified maintenance fitter, a mantle that would pass a gas company's tests (such as I have mentioned) will not sensibly diminish in candle-power in 500 hours, and will not lose more than 10 per cent in 1,000 hours of burning. The average of some tests made some time ago of vertical mantles, tested on the horizontal, shows a drop of 7 per cent., namely, from 20 to 18.6 c.-p. per cubic foot, after 806 hours of burning. The depreciation I have referred to is, of course, apart from the question of damage due to vibration or other external cause, to which, however, mantles are not now nearly as sensitive as formerly, especially when used, as they now are used to a considerable extent in London and on the Continent, for contract maintenance work without having been collodionised, *i.e.*, without having been dipped in a solution of collodion to enable them to be more readily handled before use, the coating of collodion being flared off when the mantle is fitted on the burner. The omission of this process reduces the cost and prolongs the life and lighting power of a mantle.

In actual practice, the efficient life of a mantle on a burner properly maintained averages from 500 to 600 lighting hours in public lamps. The "best on record" that I know of was a mantle that gave a good light in a lamp in St. James's Park for two years—say 8,000 lighting hours—and became an object of great affection to the lamplighter, who was quite grieved when the mantle at last broke down.

In private installations, including factories, public houses, and other premises where the percentage of breakages from external causes is highest (and which are the first to be placed under contract when such a service is offered by a gas company), the average life is about one-half the before-mentioned number of lighting hours, leading to an average use of about 5 to 7 mantles per burner per annum. In residences, on the other hand, the average life is generally higher.

On the question of how one is to determine when a mantle requires renewal because of diminished candle-power, I would say that that is generally very easily judged by the eye of the experienced maintenance fitter, and there are very generally other similar burners at hand which enable a comparison to be made. Moreover, the general experience is that mantles need to be renewed from external causes more often than because their light-giving power has appreciably diminished by lapse of time.

The quality of mantles is steadily improving in the direction of both illuminating power and durability; whilst the extended use of non-collodionized mantles by gas undertakings —introduced into this country by Mr. Corbet Woodall, as a result of his observations of the excellent results obtained in Berlin, where the average life of mantles in the public lamps in some districts is 1,000 hours, with never

a defect to be observed—promises to be of much value to the consumer by reducing contract charges for maintenance.

In concluding these very inadequate observations on the recent developments of gas lighting, which I feel do little to justify the honour which the Society has conferred upon me by asking me to prepare a paper on the subject, I would only say that those of us who are engaged in the gas industry, whilst looking back with some satisfaction upon the advance made in recent years, are by no means content to rest on our oars, but rather look forward with a lively expectation to further advance in the future. The efficiency of gas lighting, viewed as a problem of converting heat into light, is still very low in comparison with other methods; that is to say, the illuminating power produced is far less in relation to the energy consumed—say 125 c.-p. per 1,000 B.Th.U.—than it obviously might, and in all probability at a future date will, be, though already very far in advance of what it was in the era of luminous-burner lighting. The stimulus that is applied to all light-producing industries, both by competition and by the formation of such a Society as this for the study of the scientific application of light, will, I hope, render it possible to find fresh subject for a paper on "the development of gas lighting" before many years have gone by.

Discussion.

The President said that two or three points had struck him and he hoped more would be said upon them by Mr. Goodenough when the proper time came. He had referred to the central suspension of lamps as being radically unsound from the point of view of an illuminating engineer, but he had given no reasons for that condemnation. He congratulated the author upon the extremely excellent photographs reproduced in his paper and was wondering how he had been able to secure photographs of lamps by their own light so extraordinarily free from that obstrusive "flare" round each lamp which was so commonly met with in photographs of such scenes. He hoped they would hear in the discussion something about that very important question to the gas user of the deterioration of mantles in course of time. Again, the commercial use of non-collodionized mantles mentioned in the paper was new to him, and he hoped they would hear more about that. He asked speakers to discuss the paper on its merits in order that they might get the best information possible upon this most important branch of applied science. At the request of the Council, however, he must say a word or two in regard to the suggested lines of discussion: it was earnestly hoped that speakers would refrain from entering into any comparisons as to the merits of gas lighting and other illuminants. They were not there to discuss that question and they wished to keep away from such polemical matter and to confine themselves to the real subject of the paper.

Mr. C. Carpenter (South Metropolitan Gas Co.) first congratulated the Society on having a paper by so qualified a man as Mr. Goodenough, and secondly, on having in the chair so distinguished a physicist as Dr. Thompson. He did not remember of late years an occasion upon which a gentleman of the scientific attainments of Dr. Thompson had taken the chair at the reading of a paper on gas lighting, and he thought it could be taken as a sign of the times that it was being recognized that the knowledge of gas lighting was on a more scientific basis than was the case a year or two ago.

Dealing with the question of inverted mantles, the speaker stated that one cause of their greater efficiency, compared with the upright type, had not been mentioned in the paper. It was a physical one and he thought it happened in this way. With the ordinary burner the particles of gases arising from the burner top are in a continually increasing upward motion,

getting away as fast as possible from the mantle which it is their business to illuminate. In the case of the inverted mantle, however, the particles are first of all moving vertically downwards at a gradually decreasing rate. They come to rest and then the direction of their flow is reversed and they rise upwards, so that there is a certain pause in their flow, and it might almost be imagined that they are giving their effect in a still atmosphere, or in an atmosphere still in comparison with the lively atmosphere in which the vertical burner is burning.

The type of burner was an important matter to gas companies. It was well known that the chemical composition of town gas was not the same in all places, and for this there were very good reasons. At the present time inverted burners were sometimes fitted with gas regulators and frequently air regulators as well, in order to adjust them to the special conditions as regards the composition of the gas in each particular town. He had recently seen a suggestion that the supplier of gas in each town should select the type of burner which would give the best results in that town and that burners of that type should be supplied to the consumers. He believed this was the best system. It was a disadvantage to have an air and a gas regulator on each burner. During the past eighteen months his company had been making experiments in this direction, and the streets of South London were lighted by inverted mantles in respect of which there were no adjusters either for air or gas. Similar burners for indoor lighting had also been under test and were now ready to be supplied in South London for the coming winter. They had no adjusters and were simply slipped into a socket just like an electric lamp. Such a burner had the additional advantage that it was easily cleaned. This was a distinct advantage in such a city as London, where, owing to the large amount of dust in the atmosphere, it was particularly essential that burners should be capable of being readily removed for cleaning purposes.

Mr. C. W. Hastings remarked on the thoroughly practical nature of the paper. Reference had been made to the need for exactitude as regards pressure; in domestic lighting pressure was the *crux* of the whole question.

He would like to ask Mr. Goodenough whether, in connexion with his company, he had taken steps to bring the pressure of gas supplied to a normal figure by placing a governor or regulator on the company's side of the meter so that the consumer actually knew what pressure was being supplied to his house.

The new variety of burner mentioned by Mr. Carpenter seemed to get over many difficulties.

Mr. W. H. Y. Webber heartily supported the author in his objection to central or axial lighting of main thoroughfares in towns. It was the wrong place for street lamps for several reasons. In the first place, it put most of the light where it was not wanted, and, secondly, the direction of the light was unfortunate for both vehicular and pedestrian traffic. With such lighting, all omnibuses travelled with their entrance sides in the shade and it was very difficult to see the destination boards. Cabs must be entered and left in deep shadow. In the case of vans unloading at a warehouse, the inside of the van was quite dark; and it was difficult to ensure that entrances to warehouses, if they were at all deep, were efficiently lighted so far as the main door. A friend of his had observed a guardian of the peace enjoying a quiet smoke in one of the shaded doorways in Cannon Street; and if this were so, this method of lighting might equally offer shelter for burglars. Street lighting was required more for pedestrians than for the central line of traffic. He thought the paper showed, probably more than anything else, the enormous advance made in the efficiency of gas lamps during recent years, and this was due to the perseverance of the manufacturers stimulated by the advice and criticism of those who were labouring in this department of engineering, viz., the officers of the gas companies.

Dr. R. Lessing agreed that the high efficiency of inverted burners was

mainly a matter of flame temperature. There could also be no question that it was the temperature of an incandescent body that was mainly responsible for its efficiency, and it had been shown that an increase in temperature of 100 degrees might double the lighting power of a burner.

As regarded flame temperature, it was, of course, recognized that the Bunsen flame was divided into several zones of varying temperature. Allowing a flame to burn as in the laboratory one found that there was an inner cone which was comparatively cool, while the outer one, which received sufficient air for theoretically complete combustion to take place, was therefore very hot in comparison. If they added to the gas sufficient air to obtain the theoretical combustion throughout the flame they would be in a position to place the body of the mantle in the hottest zone, and the bunsen flame would assume an almost homogeneous aspect throughout. On the other hand the flame would be considerably shortened, and a second advantage was obtained in that the heat given out by the flame was more concentrated on the body heated. Therefore some regulation of the air-supply seemed to him necessary, though he would not like to disagree with Mr. Carpenter as to the advantage that would accrue from burners that could be worked without regulation of air, especially in view of the fact that every consumer was not capable of making the minute adjustments required. On the other hand every undertaking was not in the happy position of Mr. Carpenter's of having gas of practically constant composition.

There was another point mentioned in the paper, namely, the preheating of the gas and air mixture, and this indicated that they were beginning to understand the scientific basis underlying the whole question much better than a few years ago. It was now possible to construct lamps to such a nicety that the excess of air in the products of combustion was reduced to a minimum and nearly all the heat obtainable was applied to heating the mantle. To enable a rapid exchange of heat to take place one should aim at exposing a large surface, which should be as thin as the construction would allow without deterioration from the heat.

The temperature of the flue-gases was an important item in the working of the lamp ; its maximum value could be ascertained by analysis of these gases, and it could thus be readily demonstrated whether there was any excess of air present. He recalled one or two cases of modern high pressure inverted gas lamps where it had been possible, by investigations of this kind, to reduce the excess of air by about 30 to 40 per cent. of that present in the case of previous designs, and to improve the efficiency of the lamp to a corresponding extent.

Mr. W. J. A. Butterfield agreed that centrally suspended lamps were objectionable not only on the grounds already mentioned, but also because they interfered with the passage of fire-escapes, ladders, and possibly tramway conductors.

He was also glad to hear Mr. Goodenough's experience as regards maintenance. When he had been preparing a textbook on another illuminant some years ago he had been very glad to have indisputable figures on the cost of maintenance to go upon. The fact that a gas company were prepared to renew mantles and chimneys for a certain sum per quarter afforded a safe basis on which to compute costs of gaslighting.

Speaking as a private householder he had had very favourable experience of incandescent lighting. There had been one case in which a mantle on a Kern No. 3 burner had lasted for three years, with a loss in candle power of only about 15 per cent, while the one that replaced it, in his entrance hall, and therefore subject to draughts, had already been in use for $2\frac{3}{4}$ years.

He could fully confirm what Mr. Carpenter had said about the efficiency of his burner with neither gas nor air regulation; of course such burners had to be standardized for the particular quality of gas for which they were intended. It was curious that they were going back to the fixed relation

of gas and air in the burner for lighting whilst the makers of stoves for heating purposes were proceeding in the other direction.

Mr. A. E. Broadberry (Tottenham Gas Co.) after adding his congratulations to the author for the paper, said he wished that certain points had been dealt with in greater detail. With regard to high pressure lighting generally, there was no doubt that this would constantly increase, and that even for ordinary supply there would be a distinct tendency to increase the pressure. Personally he felt that they were merely on the outskirts of what could be obtained with gas, and that in a few years time they would look back upon their present systems as being just as old-fashioned as those of ten years ago are regarded now.

Mr. S. E. Doane (Chief Engineer, National Electric Lamp Association, U.S.A.) expressed his thanks for the courtesy and kindness which had been extended to him during his two months' stay in this country. Whilst he was not qualified to speak in the discussion upon this gas paper, he wished to mention that one of the greatest benefits accruing from the work of the American Illuminating Engineering Society was the lively interest in illumination they had awakened among architects.

Architects now came to the American society for specifications and assistance and they also now took the advice of consulting illuminating engineers as the result of the work of the Society. Another achievement in America was the institution of a series of lectures at the Johns Hopkins University and these had been attended by consulting engineers, architects and even professors at the different colleges. The latter had gone back and started lectures of their own as a result. The Illuminating Engineering Society in England was well qualified to carry on similar work.

Mr. S. E. Thornton (Messrs. William Sugg & Co., Ltd.), thought that it would be an advantage to the general gas-using public if this paper were brought to their notice, as it contained some good practical information.

With reference to Street Lighting, he suggested that in view of the many beautiful buildings which London possesses, more consideration should be paid by the Lighting Authorities to illuminate (or to throw some light on) these buildings. It would greatly add to the interest and beauty of London's streets by night.

He was not sure, however, that the ratepayers would all agree with him in this suggestion.

Mr. R. W. Edwards (Aldershot Gas Water, and District Lighting Co.), whilst congratulating Mr. Goodenough on the excellency of his paper, also reproved him for his brevity. There were many points in the paper upon which more information would have been desirable and acceptable. Firstly, in regard to the maintenance of incandescent burners—did the author advise consumers upon the basis of an exclusive charge at so much per quarter per burner, to include labour ? Or did he suggest providing material at cost price, or something near to it, and labour free ? or, as third system, did he suggest doing the labour at say 1d. per burner per visit, and charging for material at a low rate ?

Next, with regard to cross lighting of public streets—years ago he remembered a street in Liverpool, called Bold Street—a somewhat narrow, but nevertheless very important thoroughfare—which was lighted by central wires slung across, and was quite satisfactory. Personally he thought that in narrow thoroughfares cross lighting was much more effective and more efficient than side lights. The latter was the better with wide thoroughfares having broad footpaths. He had also noticed, and admired the efficiency of the cross lighting in the Friedrich-Strasse, Berlin.

Again, he would like to seek some information with regard to high-pressure lighting. What system of high-pressure distribution was in use by Mr. Goodenough ?—Was the gas compressed from a central compressor ? or from de-centralized compressors ? What motive power was used ? and whether there was auxiliary motive power ? *i.e.*, if by water, gas engines, or electrical motors ? Further, had

he any system whereby he mixed gas with an equal proportion of air at the compressor, as was being done in the installation at the Brighton Railway Station, the remainder of the air being taken up at the burner ?

These were important points, and of much interest to the present-day generation.

He thought that the fact that Mr. Carpenter was using incandescent inverted burners without regulators spoke well for the manufacturing arrangements at his various works, but there were difficulties in the way where a system of mixed gases was in use, which was not the case with Mr. Carpenter's company. In these cases with mixed gases, there was not the same degree of constancy in the composition and specific gravity, and therefore regulators on the incandescent burners would be a necessity. He was carrying out some rather exhaustive experiments in some outlying districts (through which the gas was being boosted at a high pressure of 2 lbs. per square inch to districts beyond) in regard to pressure on the consumers' premises, and was fixing regulators adjusted to a maximum of 3 in. on in-let of consumers' meters, and so far this had been very satisfactory. The consumers were delighted because the adjustment of the burners was more perfect, and generally the gas supply, including that to the cookers and fires, more efficient. It was also a matter of importance to fix the regulator on in-let of meter, because of the compression of the gas, in order that greater accuracy could be obtained in registration, and furthermore to protect the drum of the meter from any strain.

Mr. C. Carpenter interposed with the remark that the non-adjustable burner which he had already mentioned, had been working satisfactorily in Westminster on the Gas Light & Coke Co.'s supply for twelve months.

Mr. J. H. A. Baugh suggested that a more effective illumination would be obtained on railway stations if a globe composed of slightly ground glass was used instead of a clear globe, as this gave rise to an impression of glare. The same thing applied to some extent in the case of street lighting. Screening might also be of assistance in distributing the light ; for the same reason smaller units, at more frequent intervals than at present, would be found beneficial.

The President, before calling on the author to reply, made a few remarks. One gentleman had expressed surprise that a physicist should take an interest in gas lighting. But surely the extraordinary fact that, whereas a few years ago they were only getting two or three candle-power per cubic foot of gas, they were now getting up to 70 candle-power by the use of mantles, and inversion, and high pressure, must interest every scientific man from whatever quarter he might happen to come. They must not too forget that the historic room in which they were meeting and which had been the scene of scientific meetings for over half a century, had witnessed the birth of gas lighting and that discourses were delivered there the best part of a century ago by the late Mr. Winsor upon the great importance of laying down pipes in London for the first chartered gas company. Not very many years ago he heard a lecture in that very room in which the lecturer was quite confident that he had lived through the gas era and that it had about closed. After hearing the discussion on Mr. Goodenough's paper they would begin to think that, whatever Mr. Winsor did in 1808, the era of real gas lighting had only begun.

Mr. Goodenough, in reply, remarked that his paper had been criticized as being too short. He thought the shortness of the paper was justified by the fact that it had given time for the discussion ; the remarks that had fallen from the various speakers having been more valuable than anything he was himself able to say. Dealing first with the President's challenge as to why he considered the lighting of the roadway by lamps suspended over it as unsound, Mr. Webber had partially answered the question. The light tended to throw shadows from vehicles on to the pavement; and a

person trying to see the destination of an omnibus had the disadvantage of having the side of the vehicle in shadow instead of in light; and if he attempted to get into the vehicle, he also found the entrance in shadow. There was another very strong objection to the lighting of the roadway by suspension lamps. It was this: They had to have the lamps sufficiently high above the roadway for the wires to be cleared by the passage of fire escapes or tall ladders; and if they were put sufficiently high to ensure anything like even distribution of light on the pavement, they were so high that, if there was a fog, there was not the slightest chance of the road and pathways being lighted by the lamps, situated (say) 28 or 30 ft. above the roadway. Most of them had had experience of fogs in London. He had looked down from one of the windows of his flat through the clear upper air on to a dense bed of fog beneath, with an arc lamp shining merrily above the fog. He had gone down, and stood at the foot of the column, and could not see the light, though the lamp was only 18 ft. above the road-level. If the height of such a lamp was increased to (say) 28 ft., the chances of the light finding its way down to the street when a real fog prevailed were very remote. He had to thank Mr. Carpenter for the very complimentary remarks he had made; and he did feel that the paper had been justified if only by securing Mr. Carpenter's presence, and hearing what he had to say on gas-lighting matters, upon which he was such an eminent authority. He (Mr. Goodenough) was particularly interested in Mr. Carpenter's explanation of the causes of the efficiency of the inverted gas-burner as against the upright form—an explanation that had not previously occurred to him. He was glad that Dr. Lessing confirmed him in his belief as to the main cause of the increased efficiency. Particularly interested would he be to see and to test the burner of which Mr. Carpenter had spoken with its fixed gas and air supply; more especially as Mr. Carpenter was able to assure them that it had been found to work with perfect satisfaction upon the Gaslight Company's supply—namely, a mixture of coal and water gas, distinct from the straight coal-gas supply in South London. He had quite an open mind on the subject. There was one point that occurred to him, and it was that the adjustable nipple by which the supply of gas was regulated served the double purpose of regulating the gas and of clearing the nipple from any temporary obstruction that might be in it without dismantling the lamp for the purpose. A turn of the regulating screw to and fro, so as to drive the needle through the injector and back again, would often improve—would often make a substantial improvement in—a defective light. Mr. Hastings raised the question of pressure. The variations of pressure in a district were not, as he had said in his paper, by any means so material as at one time they were. Owing to the considerable higher average pressure that was now in use in the district—say, 3 in. instead of perhaps 1½ in. as formerly — a ¼-in. variation in pressure was not nearly so high a proportional variation as it was when pressures were lower—that was to say, a difference between 1½ in. and 1¼ in. was proportionally much greater than a difference between 3 in. and 2¾ in. He had been told by a gentleman interested in the manufacture of instruments of precision in regard to pressures and so forth, that he had never found in his experience a straighter line on his recording-gauge than he found in Westminster nowadays. A great deal, of course, depended on the adequacy or inadequacy of the internal fittings. If the fittings internally were of a limited character, then there would be variations in pressure (even though the district pressure was constant) according to the demand made upon the supply. This was a point upon which they would be glad if architects would consult the gas company when drawing up their specifications for the piping of premises. There was a great tendency to put in internal piping when houses were in course of construction that was altogether inadequate. With adequate fittings, there was little need in most

districts for pressure governing; but where internal fittings were at all on the small side, it was undoubtedly a great advantage to fix a governor on the outlet or inlet of the meter, so as to secure a constant pressure at the burners whatever the demand might be. Mr. Butterfield gave them some interesting experiences in regard to the life of mantles. He (Mr. Goodenough) was interested to read in the *Journal of Gas Lighting* that day a report from the Chief Inspector of the Brentford Gas Company of their experience in the use of mantles on high-pressure lamps at the Japan-British Exhibition, where their average for six months was not two mantles per burner. This would probably give five mantles per annum, allowing for the fact that the months of use were summer and not winter ones. Mr. Thornton's suggestion as to the illumination of fine public buildings would commend itself to gas and electric lighting companies, but perhaps not to the ratepayers. (Laughter.) Anyway, he (Mr. Goodenough) would welcome the adoption of the suggestion. Mr. Edwards asked for an expression of opinion as to the best system of charging for mantle maintenance—whether he would advise an inclusive charge (a fixed price per annum or quarter to include all materials and labour), or whether he would recommend materials at cost and labour free. He was a strong advocate of the system of charging fixed prices per burner inclusive, because he did not like leaving to the decision of a consumer whether a mantle should be continued in use or not. If a consumer had to pay so much per mantle, according to the number of mantles used, the consumer's tendency would probably be (as it was when they looked after their own mantles) towards economy rather than efficiency. He (Mr. Goodenough) preferred that it should be a matter for the decision of the gas company's fitter as to whether or not a mantle was required rather than leave the decision to the consumer, if the consumer had to pay. For these reasons, he strongly recommended an inclusive charge per annum or per quarter. Mr. Edwards also referred to central lighting for narrow streets; and, for such purposes, he (Mr. Goodenough) thought that bracket lighting was preferable as freeing the streets from any obstruction from columns, which were perhaps a nuisance in narrow thoroughfares. A great majority of the narrow streets in the City were well lighted from brackets. Then, Mr. Edwards also asked as to the system of high-pressure distribution. The Gaslight and Coke Company were supplying high-pressure gas for lighting in Westminster from a central station at their head office in Horseferry Road—the compressors being run by gas-engines with adequate stand-by; so that if one engine was not available, another was. In regard to the question of supplying a mixture of gas and air at the compressors, instead of the mixture taking place at the burner, they had not put in any installations of this nature themselves, but there were one or two on their district. The suggestion that more standards should be used in the streets was one that was rather difficult to deal with, because there was such an enormous variation as to the number of standards that were used in streets. In some streets, the number of standards was very considerable per thousand yards; in others, very scanty. Personally, he favoured the use of a number of units of moderate power, placed not too high above the ground, rather than lighting the streets by high units placed a greater distance apart, and fixed higher above the ground-level. By these means, better uniformity in the distribution of illumination was obtained.

The **President** remarked that, as regarded central lighting, he did not find himself in antagonism to the author. But it appeared to him that many of the objections raised to centrally suspended lamps also applied to central pillars.

The President then proceeded to mention that a series of queries connected with gaslighting had been prepared by the Hon. Secretary and submitted to several authorities, some of whom, including Mr. Geo. Keith and Mons. P. Lauriol (Paris), had

already sent in written communications. These he proceeded to summarise. (These remarks will be found *in extenso* on p. 733.)

On the motion of the President, a hearty vote of thanks was accorded to Mr. Goodenough.

The President then announced that the **next meeting** would be held on **Friday, December 9th,** when **Prof. E. W. Marchant** would read a paper on 'Recent Progress in Electric Lighting,' and the proceedings terminated.

Queries in Connexion with Gas Lighting.

In view of the rapid progress made and the many different forms of lamps and appliances now available in connexion with gas lighting the following list of queries, dealing with points on which more definite information would seem to be valuable, was prepared and published in the last number of *The Illuminating Engineer* (p. 671).

This series of inquiries has now been submitted to authorities on gaslighting in this and other countries, from some of whom we publish replies in this issue. The following is the list of queries submitted:—

1. What is the maximum efficiency (candle-power per cubic foot of gas consumed per hour) attainable in practice at the present time, and under what conditions as regards pressure, &c.? What do you consider the most accurate method of expressing this quantity (*i.e.*, in terms of mean spherical, mean hemispherical or candle power in some prescribed direction)?

2. How long, on the average, should mantles intended (1) for low pressure indoor lighting, (2) for outdoor high pressure lighting, be allowed to be used before they are replaced? How much should their light be allowed to decrease before renewal, and how is this tested? Results of tests of the fall of candle-power during life of modern low and high-pressure mantles would be welcomed.

3. Under what conditions, in your experience, has automatic control of lamps been found economical and reliable?

4. How far has it been found beneficial for the company to supervise the conditions of lighting enjoyed by the consumer, undertake the adjustment and cleaning of burners, globes, &c., and the replacement of mantles; should companies also give advice as to the location and use of lamps? In your experience is it the practice of companies, in buying mantles, to require compliance with a certain specification and what terms does it contain?

5. In view of the greater intrinsic brilliancy of modern high candle-power lamps is it desirable that some form of diffusing globe should be employed to screen high-pressure lamps in the streets and interiors?

In the following pages we publish the replies to this list of queries received from corresponding members in different parts of the world. It should also be mentioned that letters expressing sympathy with the work of the society and interest in this discussion have been received from Prof. H. Bunte (Technische Hochschule, Karlsruhe), Mr. W. H. Gartley (Chief Engineer of the Philadelphia Gas Works, &c.), and others, and we hope to be in a position to publish further communications from other corresponding members of the society very shortly.

Communicated Replies.

M. P. Lauriol (Chief Engineer of the Lighting Department of the City of Paris) :—

Query 1. When comparing ordinary upright incandescent burners, it is only necessary to measure the horizontal intensity, as the form of the intensity curve will be the same for different burners ; but a measurement in one direction only is not sufficient, as the value in different directions may vary as much as 10 per cent from the average value. Measurement in four directions at right angles is suggested as satisfactory.

A comparison of upright and inverted burners for street lighting should be on the basis of the mean lower hemispherical intensity.

In the case of interior lighting, the question of the best basis of comparison is more difficult to settle. In some cases the hemispherical and in others the spherical intensity would be the most satisfactory, according to the quantity of light that may be reflected from the ceiling and walls. In general the mean spherical intensity is to be preferred.

The following figures give the results of some recent tests on efficiency attainable with Paris gas (tested according to the method of Dumas and Regnault for the candle-power of flame burners) and also tested in the laboratory for calorific power, giving practically 4800 calories per cubic metre (steam not condensed). The figures are given in international candles, and are the average values for 400 hours working, the efficiency being actually about 10 per cent lower at the end of 400 hours.

Ordinary burners, with ordinary pressure of 50 mm. (2 in.) of water :—

*Small burner, consuming 50 litres (1¾ cubic feet) per hour, 1·25 litres per candle hour (23 candles per cubic foot).

*Medium burner, consuming 80 litres (2·8 cubic feet) per hour, 0·95 litres per candle hour (30 candles per cubic foot).

*Large burner, consuming 150 litres (5¼ cubic feet) per hour, 1·30 litres per candle hour (22 candles per cubic feet).

Thus the medium burner gives the highest efficiency.

Inverted burners :—

†Pressure 50 mm (2 in.) ; burner of 80 litres (2·8 cubic feet) per hour ; consumption, 1·38 litres per candle hour (21 candles per cubic foot).

†Pressure, 1400 mm. (55 in.) ; burner of 300–2500 litres per hour (10½–87 cubic feet) ; consumption, 0·67 litres per candle hour (43 candles per cubic foot).

Query 2.—With ordinary pressure (50 mm. or 2 in.) good mantles last 400 hours with a decrease of 20 per cent from the initial efficiency. This applies only to laboratory experience, as we have no practical method of measuring the candle-power of street burners when working.

Query 3.—No experience.

Query 4.—The Paris Gas Co. supplies gas, meters, and small cooking ovens, but nothing else.

For municipal lighting, both for streets and interiors, mantles are bought by the municipality without any specification in the contracts. It is usual to buy from several firms at the same time, any make that proves unsatisfactory being subsequently rejected.

Query 5.—The intrinsic brilliancy of any lamp is too high for direct light to be allowed to enter the eye direct, and screening either with diffusing globes or with thick opaque paper or thin metal shades, is desirable in the case of indoor lighting. For street lighting diffusing globes are at present used with electric arcs, but not for gas lamps however powerful they may

* Mean horizontal intensity.

* Mean horizontal intensity.

† Mean hemispherical intensity.

be. But it is not certain what the future practice in this respect may be.

Additional Note.—In the case of an incandescent burner the higher the pressure at the nozzle of the burner, the higher the efficiency, provided that the burner has been designed for this pressure. In practice it is therefore desirable (*a*) to maintain the pressure at the burner constant, (*b*) to keep this pressure as near as possible to the high limit.

Now a gas-governor cannot raise the pressure above the value of the supply; it can only reduce the pressure in the burner to a certain limit "p," for which the burner is designed. Consequently when the pressure in the pipes is less than "p" the governor cannot achieve its purpose. Therefore it is desirable to maintain in the pipes a somewhat higher pressure than this value "p," and also to design both governor and burners for use on the highest pressure that can actually be attained in the pipes during lighting hours. In Paris the contract entered into with the gas company specifies that the pressure at any point in the street network must not be less than 40 millimetres (1·6 ins.) of water. In practice it is always maintained at a somewhat higher value, and the burners and governors in use are designed for a pressure of 50 millimetres (2 ins.).

Mr. Geo. Keith (London) :—

It is naturally not possible to give the maximum efficiency in candle-power per cubic foot of gas consumed per hour, unless it is known what kind of gas is to be used, as the results vary considerably according to the quality.

In my experience, however, one can obtain on the average 60 candles per cubic foot, and in some cases, where extra good coal gas is obtainable, we have obtained results as high as 73 candles per cubic foot. As an illustration of the dependence of the results on the quality of gas it may be said that, using our system with oil-gas, and that only in small units, we have obtained as high a result as 120 candles per cubic foot of gas consumed.

The pressure we employ is ordinarily 54 inches of water (or 2 lb. per square inch), but we occasionally go higher than this if necessary.

In my opinion the most accurate method of expressing the lighting value of a lamp is unquestionably in terms of the mean lower hemispherical value.

As regards query 5—in my opinion it is not necessary or desirable to use a diffusing globe with lamps for outside lighting, as the light is already very well diffused, and is not sufficiently concentrated to cause discomfort or injury to eyesight.

For inside lighting, in cases in which small units are used close to the eye, it is often found desirable to shield the eye from the direct light of the mantle by opal or frosted glass.

Prof. H. Strache (Techn. Hochschule, Vienna) :—

1. The maximum efficiency which was attained in tests undertaken last year in the Testing Institution for Gas Lighting of the Vienna Technische Hochschule, was stated to be 0·697 litre per hefner candle sub-hemispherical (37·0 Int. candles per cubic foot), with a gas pressure of 50 mm. (at 0°C. and 700 mm. barometric pressure). The caloric value of the gas was 4880 Cal. per cubic meter.

In the above-mentioned institution the mean hemispherical efficiency of the source of light (unless any other particular method is specially desired) is determined as follows: The burner is rotated around its vertical axes and readings are taken in eight different positions. Subsequently readings at intervals of 10 degrees in a vertical flame are taken, and the polar curve obtained. Then the calculation is made by aid of the Rousseau curve in the usual way.

2. The renewal of the mantles intended for out-door lighting should be effected when their efficiency has diminished by 20 per cent. Tests concerning the efficiency of street lamps are seldom taken, but when this is done the Brodhun street photometer is generally employed.

4. In our most important gas works the adjustment and cleaning of globes,

as well as the replacement of mantles, is not carried out by the gas company itself, but especially by sellers of mantles. Small gas works sometimes undertake this maintenance for some fixed price. It would be very beneficial if all gas companies would do so, seeing that the adjustment and cleaning of burners is not only in the interest of the gas companies, but would be welcomed by the consumers. Another beneficial plan would be for both gas or electric burners to be maintained by some independent company for a fixed price per annum.

5. It is not necessary to screen high-pressure lamps in the streets with some form of diffusing globe since the intrinsic brilliancy of such mantles is very much less than that of the electric light.

Experience of the high pressure street gas lighting in Berlin suggests that the eye is not too much affected by the glare of open pressure-gas lighting; but indoors it is advisable to screen high-pressure gas lamps by some diffusing globe.

Herr M. Scholz (Director of Messrs. Ehrich & Graetz, BERLIN) :—

1. The maximum efficiency obtainable in practice at the present time is according to my experience with Graetzin high-pressure gas lamps 4,600 British candles at a gas-consumption of 71·4 cubic feet, which corresponds to 64·3 candles per cubic foot. The pressure used amounts to about 54 in. water; the highest efficiency attainable with low-pressure gas lamps is 42·9 candles per cubic foot; this efficiency is obtained with "Triumph" Graetzin low-pressure high candle-power lamps of about 920 British candles at a gas consumption of 21·4 cubic feet per hour, and it may be pointed out that this lamp produces its highest candle-power (1100 c.-p.) at an angle of about 40–50°. The accompanying curve of this lamp shows that its light-distribution resembles that of the high-pressure gas lamp, and is of the best type for street lighting purposes. The high efficiency mentioned above has been obtained by super-heating both the primary air supply, and the gas and air mixture. The pressure of this lamp is controlled by an automatic gas governor arranged on top which keeps the gas inside the lamp under a constant pressure of 1·35 in. Another type yielding about 550 British candles at a gas consumption of 14·2 cubic feet per hour (equal to 38·7 candles per cubic foot) is being extensively employed in the lighting of Berlin.

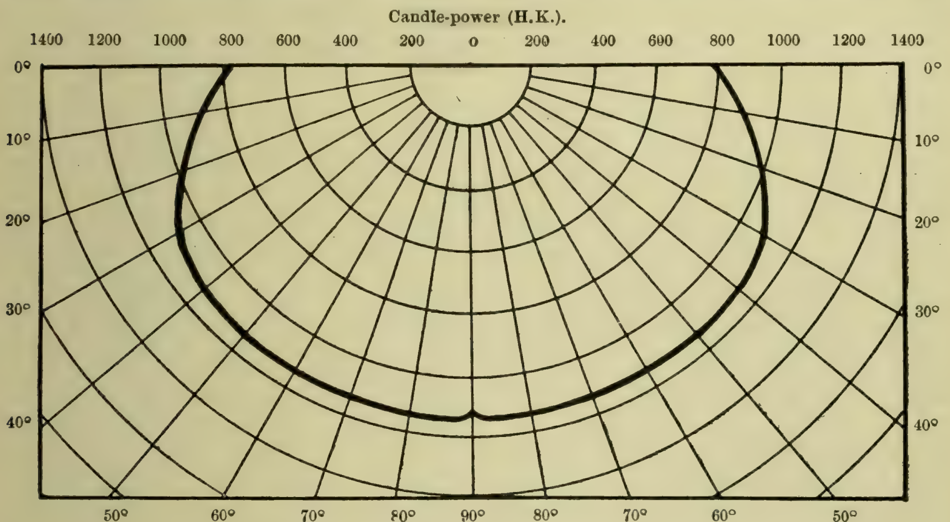


FIG. 1.—Polar Curve of Graetzin Three-Flame 1000 H.K. Light.

The most accurate method of expressing the efficiency of a lamp is, in my opinion the calculation of the mean lower hemispherical candle-power, the measurements of the different angles to be taken at intervals of 10 degrees.

2. The average life of a mantle for low pressure indoor and outdoor lighting should not be less than 500 burning hours, for outdoor high-pressure lighting not less than 200–300 burning hours. It depends, however, entirely on the quality of mantle used. It is essential only to make use of the very best quality, especially in the case of high-pressure lighting.

Results of tests showing the fall of candle-power during the life of modern low and high-pressure mantles are at the present time not at my disposal.

3. We are about to study this question, but at the present time I cannot give any definite information.

5. I do not think it desirable to provide high-pressure gas lamps with some form of diffusing globe, the intrinsic brilliancy of these lamps not being sufficient to injure the eyes of the public, provided always the lamp is not hung any lower than 17 ft. (height of the mantles above the road-surface).

Incandescent Gas Lighting.

By M. C. Whitaker.

(Some Notes on a Paper read before the Philadelphia Section of the Illuminating Engineering Society, U.S.A. May, 1910.)

In this paper Mr. Whitaker reviews the recent progress in incandescent gas lighting. Seeing that this number of the Journal is specially devoted to this subject, it occurred to us that a summary of some of the main points raised might be of interest.

Fixtures.

There has been a marked improvement in fixture design both in regard to artistic effect and structural value, but there is still a tendency to keep prices far too low to produce really satisfactory fixtures. Manufacturers are, however, quite ready to meet any exacting conditions that the architect or illuminating engineer may choose to impose. It is a question for *co-operation.*

Electric Gas Ignition.

There are two important methods of ignition commonly adopted. In the one case, a wire filament is heated to incandescence by an electric current in order to ignite the flame. In the other method a special platinum alloy filament is heated by catalytic action when placed in the path of a mixture of gas and air, and finally becomes incandescent and ignites the gas. The difficulty with the latter method is to control the action of the gas so as to prevent it from continuing too long and melting the filament.

The most recent form of igniter combines the above principles, that is to say the initial heating of the filament is brought about by a current from a dry cell, whilst the kindling temperature is subsequently reached by the catalytic action of the gas. The dry cell is arranged to produce a temperature in the filament high enough to induce catalytic action, say 500°C. The igniter is then designed so that the amount of gas and air mixture admitted to the filament is limited to that necessary to raise the temperature of the filament to the kindling point of the mixture (say from 1500° to 1600° C.). Finally it is of importance that the apparatus should be so designed that as soon as ignition has taken place, any stray currents of active mixture are automatically swept out or exploded in order to avoid risk of the filament temperature being brought too near the melting-point by this means.

In the simplest arrangement the act

of pulling a chain to turn on the gas tap makes the electrical circuit for igniting the burner; when the lighting chain is released the lever falls back and breaks the electric circuit, but leaves the gas on. Another device uses a magnetic cock for turning on and off the gas, with an attachment to close the lighting circuit when required.

Outside and Indoor Lighting.

The problem of constructing a lamp to withstand thoroughly the elements, and yet to give good combustion has been attacked with much success, especially in inverted lamps.

The author refers to the standardization of single unit burners in two sizes; one for use with a mantle $3\frac{1}{2}$ in. by 1 in., and the other for a smaller mantle, $2\frac{1}{2}$ in. by $\frac{5}{8}$ in. These two sizes are becoming almost exclusively used.

Mantles.

It is possible for the mantle manufacturer to control the colour of the light from mantles within certain limits, but up to the present the demand has been almost exclusively for mantles yielding a white light.

It is found that when the proportions of the constituents are 99 per cent. oxide of thorium and 1 per cent. oxide of cerium, the most efficient light is produced. The curve in Fig. 1 shows the change in illuminating power according to the percentage of ceria, and a progressive colour change is found to take place at the same time from purplish-white to orange-yellow.

Ramie fibre gives a much stronger mantle than cotton, and the shrinkage and change of shape is much less; the mantle is, however, much more brittle. The deterioration in light amounts to from 35 or 40 per cent. in a 1,000 hours for cotton, but is only 15 or 20 per cent. for Ramie. The best results, however, have been obtained with artificial fibre made from cellulose. In this case, it is stated, there is practically no deterioration after 2,000 hours and only 5 to 10 per cent. after 4,000 hours.

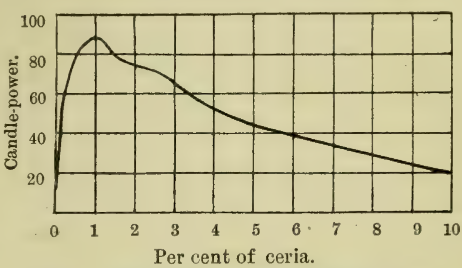


Fig. 1.—Relation between candle-power and per cent. of ceria.

Photographs of mantles are given in the paper showing the shrinkage after periods of burning ranging from 100 hours to 4,000 hours. In this way it is possible to follow closely the progressive physical changes that take place as well as to determine, by photometric measurement, the decrease of illuminating power, during the life of a mantle.

Finally reference is made to the problem of satisfactory packing. The author points out how square boxes are replacing the old cylindrical form, on account of their many advantages, especially in regard to the ease of removal of the mantle from the box.

New Developments in Gas Lighting.

By F. Lebeis (Berlin).

(Notes on a recent paper read before the German Institution of Gas Engineers; *Journal für Gasbeleuchtung Wasserversorgung*, November 12th, 1910.)

In the last article some reference was made to recent progress in gas lighting in the United States. It is interesting to observe that a paper on a similar subject was recently read by Herr Lebeis in Berlin.

One of the points discussed was the alleged superiority of the inverted to the upright mantle, which, he suggested, was not so great as was sometimes supposed. The inverted mantle is certainly a great advance on the *old* upright type; but improved design has led to a considerably greater efficiency on the part of upright burners of recent years. Moreover, Herr Lebeis

added, there are some cases in which an upright mantle is better than an inverted one. For example in some interiors an inverted light is not satisfactory because, while it accentuates the illumination below the lamp, it throws relatively little light on to the walls and ceiling of a room, so that they appear relatively subdued and in the shadow, and their æsthetic value is somewhat lost. Again, it is well known that the upright burner is less affected by fluctuations in pressure and easier to adjust than the inverted type. In street lighting the inverted light has recently been given the preference but in many towns financial considerations do not allow this replacement to take place.

The author, therefore, thought it of interest to mention a new type of burner, called the "Gobobrenner," brought out by the Deutsche Gasglühlicht Aktiengesellschaft. The essential point in this burner is that the tube conveying the gas up to the mantle is supplied with a non-conducting covering insulating it from the outside air so that less heat is lost by radiation and by conduction to the metal gallery of the burner, and substantial increase in flame temperature is said to be secured. In this upright mantle a consumption of only 1 litre per H.K. is secured (25·2 candles per cubic foot). Another improvement recently introduced consists in a form of regenerative inverted lamp capable of burning on ordinary pressure of 40 millimetres and without any special compressing apparatus, in which a consumption of 0·69 litres per H.K. (approx. 37·5 candles per cubic foot) and 200, 600, or 1,000 candle-power can be secured.

In the construction of high-pressure lamps considerable progress has also been made by the utilization of the system of pre-heating not only the primary air, but also the mixture of gas and primary air supplied to the burner. The increased flame temperature resulting leads to a consumption as low as 0·4 litres per H.K. (approx. 64 candles per cubic foot). The same efficiency is secured with these lamps when high pressure air is used with gas at ordinary pressure.

The question may well be raised how far one can proceed with this increase in temperature secured by initial heating of gas and air. The author suggests, however, that the limits in this direction have been nearly reached, for any great increase would either have the effect of decomposing the illuminating gas or else would bring the mixture to the ignition point.

In the high candle-power lamps a cluster of several burners has been found preferable to one big one, partly because any failure or deterioration of one of a group of mantles has less effect on the total light, and also because special arrangements can be provided enabling a defective mantle to be replaced without the supply to the others being interrupted.

Conversazione of the Society of Architects.

On November 16th a conversazione was held to celebrate the opening of the new premises of the Society of Architects at 28, Bedford Square, London. The ground floors were transformed into refreshment rooms and the first floor into reception rooms for the occasion.

Besides the new premises an additional attraction was the exhibition of prize drawings and designs executed in competition for the travelling scholarships of the Society, and sketches and photographs of British, French, and Belgian cathedrals and churches were also on show. A number of distinguished visitors were present, including the President of the Royal Institute of British Architects and other prominent architects. There was an excellent attendance of members, many accompanied by ladies, and the evening was a most successful one.

Among other items of interest we note the opening meeting of the R.I.B.A., on Thursday, November 17th, when an address was delivered by the new President, Mr. Leonard Stokes.

A Few Queries in Connexion with Electric Lighting.

(*To which replies are invited from readers of this journal, members of the Illuminating Engineering Society, and others interested in matters connected with illumination.*)

In our last number we published a series of queries dealing with gas lighting.

Readers are aware that the next meeting of the Illuminating Engineering Society on December 9th, is to be devoted to a paper entitled 'Recent Progress in Electric Lighting' by Prof. E. W. Marchant, and in this connexion we have prepared a corresponding list of queries dealing with points on which more definite information would be of value.

We contemplate submitting this series of inquiries to authorities on electric lighting in this and other countries from whom we hope to receive much useful information:—

1. What is the maximum efficiency attainable from modern incandescent lamps, arc-lamps, vapour lamps, &c., in practice?

What do you regard as the most accurate and convenient method of expressing "efficiency" (*i.e.*, in terms of mean spherical C.P., mean hemi-spherical C.P., or candle-power in some prescribed direction; watts per C.P., C.P. per watt, or lumens per watt, &c.)?

What useful life may be looked for from modern incandescent lamps and what is the maximum number of burning hours now to be secured for under the most favourable condition from open, enclosed, and flame arc-lamps at the present time?

2. What system of electric lighting yields the closest approximation to the spectrum of daylight, and what special arrangements can be conveniently applied to obtain this result efficiently?

3. What is the best method of testing the steadiness of electric sources of light, and what variation should be regarded as permissible in practice?

4. How far is it possible and desirable for electric supply companies to assist consumers in the location and use of lamps and fixtures with a view to securing the best conditions of illumination? What form of co-operation is to be recommended for future adoption between the lamp-maker and the central station, and what facilities already exist in this direction?

5. To what extent, in your experience, will illuminating engineers be hampered in drawing up lighting specifications, by the absence of precise standardisation of lamps, lampholders, shades, and reflectors such as exists in the United States?

6. In view of the greater brilliancy of modern incandescent and arc-lamps is it desirable that some form of diffusing globe should be employed to screen lamps in the streets and in interiors?

The Generation of Electrical Power in the Future.

The most important attraction on the occasion of the opening meeting of the Institution must have been Mr. Ferranti's Presidential Address; this has been very full dealt with in the electrical papers. Mr. Ferranti, as those who knew him might readily have expected, embarked on a fascinating and imaginative discussion of the future system of generating electrical power. He drew a picture of mighty central stations distributed over Great Britain, generating energy at the mouth of a coal pit, and distributing it, in immense quantities, at the rate of one eighth of a penny per unit. Besides the application of electricity to innumerable purposes in industry and daily life, Mr. Ferranti, also pictured the fixation of nitrogen from the atmosphere on a large scale, the raising of gigantic crops as a result, and even the ultimate electrical subjugation of the weather.

Possibly few of us may live to see the conditions foreseen by Mr. Ferranti. But it is useful, sometimes, to escape from the purely practical contemplation of things as they are, and to fix our eyes on the visionary possibilities of the future; such addresses as this do much to stimulate the imagination and indirectly lead to new developments in industry which might otherwise never have been initiated.

NEW INSTALLATIONS.

Notes on the Lighting of the New Home of the Institution of Electrical Engineers.

On Thursday, November 10th, the opening meeting of the Institution of Electrical Engineers was held, and the new President, Mr. S. Z. de Ferranti, delivered his address for the session.

The meeting was also of special historic interest in view of the fact that this was the first occasion of the Institution meeting in its new home on the Victoria Embankment. It will be recalled that in June, 1908, it was decided to purchase the building, formerly belonging to the Royal College of Physicians at a cost of £50,000; in the subsequent year a further re-building and re-decoration of part of the building to suit the Institution's needs was also commenced, the architects being Messrs. H. Percy Adams, and Charles Holden.

It was naturally a matter of interest to many members to note the details of the system of lighting employed in the various rooms, and especially the lecture theatre, which was known to have been the subject of special study.

The first effect observed was the illumination of the entrance vestibule (communicating direct with the lecture theatre) by hanging clusters of lamps in cut-glass bowls. The walls and pillars are faced with white marble, with the result that an unusually high uniform brightness of the surroundings is obtained. From some figures supplied to us by a correspondent we note that the surface brightness of the floor walls and pillars is in general in the neighbourhood of 1·5 foot-candles: in some cases, however, where there are portions in comparative shadow, falling to about 0·5 foot-candles. It may be added that this principle of utilizing light tinted ceilings and surroundings has been followed throughout in the corridors and in the library of the Institution.

The most interesting feature, however, is the lighting of the lecture theatre. It was early determined to avoid anything in the nature of a glare in this room and recourse was had to a system of partial inverted lighting. The room is about 50 ft. square, and the walls are faced in mahogany. The walls terminate in a sloping white frieze round the base of which a series of 220 25 watt tungsten lamps are concealed. These lamps illuminate the frieze strongly, and the room is thus girdled with a ring of brightly illuminated white surface, from which the major part of the illumination is derived. (See Fig. 2.)

The ceiling of the room, however, consists of latticed diffusing glass divided into four portions by two white cross bars which, like the frieze, are ornamented by carving. Above each of these four portions is placed a 350 watt quartz-tube mercury vapour lamp the light from which, softened both by the globes of the lamps, and also to some extent by the latticed glass of the ceiling, streams into the room below and assists the illumination. The total consumption of power from the carbon filament lamps alone is thus of the order of 2 watts per square foot of floor-area.

We are indebted to a correspondent for some data regarding the illumination produced. The illumination on

[*By the courtesy of 'The Electrician.'*

FIG. 1.—Library at the New Home of the Institution of Electrical Engineers (London).

FIG. 2.—Showing method of indirect illumination in the Lecture Theatre at the New Home of the Institution of Electrical Engineers (taken by artificial light).

the President's and the Press table is slightly over 2 foot-candles, verging to about 1·8 as the sides of the room are approached. The illumination at different parts of the theatre averaged about 1·8 foot-candles the lowest figure recorded being about 1·4, immediately against the wall, where part of the illuminated frieze is inevitably obscured by the cornice above. It will therefore be seen that very uniform illumination over the floor area has been secured. A measurement was taken of the illumination due to the metallic filament lamps alone, the mercury lamps alone and both together. It appeared that the illumination due to the metallic filament lamps only was 1·6 foot-candles, that due to the mercury lamps slightly over 0·5. It is interesting to observe that these two individual illuminations add up very closely to what the combined illumination proved to be. We are also informed that the surface-brightness of the white frieze varied from about 5 foot-candles near the centre to nearly 10 at the corners (where there is mutual reflection between the adjacent portions of the frieze), and that the surface-brightness of the mahogany walls is about 0·3 foot-candles.

This surface-brightness of the frieze proves to be just about what theoretical considerations would suggest as being necessary to produce the given illumination.

The method of illumination employed has thus the merit that no surface of inconveniently high intrinsic brilliancy is exposed to the eye, and the combination of indirect lighting with the central direct illumination from mercury lamps is distinctly original. It may be noted that the latter throw several cross-shadows though these are naturally not very perceptible in view of the predominance of the indirect lighting which is practically shadowless.

Special arrangements are also provided for the lantern, built into a special gallery at the back of the theatre, from whence the cornice lighting is controllable in sections. The necessary switches and rheostats for the control of the lantern are provided in this chamber, and the raising and lowering of the lantern screen can also be accomplished by the lantern operator.

As regards the lighting in other portions of the building, the chief item of interest is the library, at present lighted by two parallel rows of fixtures each row containing six clusters of tungsten lamps in cut-glass bowls. The arrangements here are not yet complete as table lamps have to be added, and special lights will also be provided under the gallery to illuminate the lower shelves. The figures given by our correspondent for the present illumination of the central tables are 1 to 1·3 foot-candles, according to position, and 0·8 foot-candles for the vertical illumination on the lower book shelf.

The Common Room and Council Room are provided with chandeliers placed at intervals and fitted with tungsten lamps in frosted glass globes. It may be added that the wiring has been carried out by Messrs. Drake & Gorham on the Kalkos system, and that the cut-glass and metal work fittings are from Messrs. Osler and the Birmingham Guild respectively.

We regret that conditions of space prevent our referring to other details in the equipment of the building as fully as we should like to do. Readers who desire fuller particulars regarding other electrical details are invited to study the accounts in our contemporaries, *e.g. The Electrical Review* (Nov. 11th), *The Electrician* (Nov. 11th), &c. One special item to which attention may be directed, however, is the master clock in the Common Room, electrically controlling 14 dials, in other parts of the building. The motion of the pendulum in this case actuates a small armature which generates and transmits current to the other clocks at each swing, and renders the use of dry cells unnecessary.

In conclusion, we have only to express the hope that the great pains and trouble which have been expended on the Institution's new home will bear good fruit, and that its prosperity may be even greater in the future than in the past.

Light Conversations on Illuminating Engineering.

II.—The Illumination of the Home of the Institution of Electrical Engineers.

(The last of this Series of Conversations, devoted to "Glare," will be found in Vol. II., p. 765, 1909).

The Electrical Engineer led his guests proudly into the entrance hall.

"In this building," he said impressively, "you will see the very latest triumphs of electrical lighting. Everything has been carefully thought out. Notice, for example, this palatial white marble entrance. The reposeful monotony of shade in the white pillars, white walls, and white floor is not without intention. It inclines the mind to study. It leads us to assume, insensibly, an attitude of submissive expectation before entering the lecture theatre. Now watch !"

He opened the door of the theatre.

"What do you think of it ?" he inquired.

The Philosopher looked at him rather dubiously.

"What do *you* think of it," he rejoined, hedging.

"Well, you 've kept your beastly glaring metallic filaments out of sight, any way," said the Man of Sense cheerfully.

"Indeed we have," said the Electrical Engineer, "Here you see a complete absence of glare, and yet we have avoided the impression of flatness which is one of the chief objections urged against indirect lighting. The play of shadow in the carving of the frieze and cross pieces prevents that. And the plan of having only a narrow illuminated frieze with a square centre illuminated by the mercury lamps outside also serves to break up the ceiling and prevent monotony. And yet we also get very good illumination. Two foot-candles my friends and absolutely uniform ! and only abut 2 watts per square foot from the incandescent lamps. However, tell me again, what do you think about it ?"

"Well," said the Philosopher gravely, "The general effect seems to me somewhat too spectacular—not to say theatrical. That green light now, and the shadows of the latticed glass on the moulded edges of the frieze—Is it meant to represent moonlight—with four moons ?"

"It seems to me," said the Man of Sense, after thinking deeply, "There 's something missing somehow. You say the effect is not flat, but I can't help thinking the 'noble simplicity' of this expanse of mahogany wall produces that very impression. Somehow the place seems empty—depressing."

"Impressive you mean," suggested the Electrical Engineer.

"No, sombre—dismal."

"Subdued," said the Philosopher. "No. The feeling of restraint is quite natural and appropriate in an interior of this description. It naturally leads the mind to the contemplation of high things. It suggests serious and weighty discussions—"

"And is therefore appropriate for the meeting-place of a great Institution like this," said the Electrical Engineer delightedly before any one else could speak.

"On the whole," said the Lighting Expert, "I think we may call it a successful installation. I understand that you have used about 2 watts per square foot of floor area, and though I have often been obliged to secure as high an illumination as two foot-candles with only $\frac{3}{4}$ watts per square foot, still I think, under the circumstances, the consumption is not too high. But I question whether it would not have been better to do without the mercury lamps, or else to use more completely diffusing glass in the space below them. At present they throw rather curious cross shadows, while the

illumination without them is practically shadowless. I might suggest, too, that while you are about it you might make the brightness of the frieze uniform all the way along. It could easily be done by adjusting the candlepower of the lamps, putting in smaller units at the corners where there is cross-reflection and the brightness is intensified.

Another point is that the polished wooden border at the base of the frieze is a mistake. It leads to a certain loss of light, and gives rise to a very odd streaky and shiny appearance when viewed in certain directions.

"As regards the border," said the Electrical Engineer, "Of course I am with you. It *is* bad from the lighting standpoint, but it is rendered necessary by 'architectural considerations.' But it would be impossible to put in glass dense enough to appear uniformly lighted by the mercury lamps. It would absorb all the light in the daytime, and look horrid!"

"After all," said the Philosopher, "The architect is within his rights in insisting on his brown border. He might even go further and add that the effect of the shadows cast on the frieze by the lights below is most peculiar. Natural daylight shadow is never thrown upwards in this way. In the same way it is open to question whether people's faces appear at their best when lighted exclusively by rays from above.

"Are you sure," said the Man of Sense, "that the highly uniform illumination you have got over the floor area is a good thing? I have always imagined that a lecture hall was something like a theatre. You ought to emphasize the position of the President and the lecturer by a stronger illumination in their vicinity leaving the rest of the place relatively weakly illuminated. I believe the impression of 'something wanting' springs from the fact that there is no one point to which attention is involuntarily directed. Now the President's chair ought to be such a point. It ought also to be possible to give special local lighting to diagrams. The present illumination may be high enough as far as absolute value is concerned, but it won't make them stand out."

"For my part," said the Philosopher, "I still object to the stage moonlight. It is true that a certain interest is excited by the contrast between this green light and the brownish walls, and the effect would be distinctly monotonous without some such diversion. But it doesn't seem quite the thing for a lecture hall. If some form of lighting in the centre of the roof is needed, why not stud the various corners with symmetrically placed frosted incandescent lamps? This would relieve the monotony of the uniform illumination below."

"Well, well, well!" said the Electrical Engineer, a little staggered by the assurance of the Philosopher and the Man of Sense in having decided views on the purely technical question of lighting, "Let's go and see the rest of the building."

They passed in due course through the Common Room, the Council Room, and the Library without many comments being offered—perhaps because the Electrical Engineer, intolerant of further criticism, hurried them through rather quickly. It is true that the Philosopher, who was rather tall, complained of the obvious solidity and the low position of the fixtures in the Common Room which, he said, gave him the impression that he would bang his head if he did not move warily. In the library, however, the lighting expert cried a halt.

"Why," he said, "you have not got nearly enough vertical illumination on the lower shelf!"

The Electrical Engineer, explained hastily that more lights were to be installed for that very purpose.

"Oh! I see. But look here! Is it right for these hanging lights to be hung above the gangways? That is what they did in the Patent Office Library, you remember, with the result that they had to improve the illumination by local lamps on the central tables."

The Electrical Engineer regarded the rows of hanging fittings somewhat dubiously.

"I believe it's in accordance with architectural requirements," he said at length.

Meantime the Man of Sense had been examining the journals on the central table.

"I don't know about architectural requirements," he exclaimed, "but I do know I jolly well haven't got enough light at this table to read properly." And the Philosopher backed him up.

Some little time after the Electrical Engineer, having seen his guests safely off the premises, met Lumina.

"I don't know what people are coming to," he grumbled. "Every one seems to think he can discuss lighting nowadays.

"I shouldn't trouble too much," returned Lumina, "It is quite true that every one seems to be talking illumination now, and most people have views of their own, too. But its a good thing for you in the long run. Let them air their notions. A few years ago they wouldn't have taken enough interest to do so."

"But do you think what they said is true?"

"Well, they said rather different things. As regards the library I think I should look into that question of the illumination on the central tables, just for safety's sake, you know.

Of course the system of lighting in the theatre is somewhat novel, and some difference of opinion must be expected; so much depends on mental attitude, and until the desirability of uniform lighting has been more thoroughly discussed, we need hardly to commit ourselves to a definite opinion, nor decide too quickly that "the last word" has been said as regards electric interior lighting. We must *wait and see.*

Moreover it need not be assumed that this is a completely-finished installation. Any new effort of this kind must be considered to some extent experimental, and I feel quite sure that, if it appears that the present system might profitably be supplemented by other special arrangements, the Institution will be only too glad to consider modifications in order to get the very best conditions which present experience can suggest.

Meantime, you have got at least two things to congratulate yourself upon. *Firstly*, you have got an installation expressly designed to avoid glare, and that's one important point. *Secondly*, whatever the results, the illumination has at least been scientifically designed and thought out on a definite plan. A few years ago the thing would have been left very much to fate. Now the Institution has shown its appreciation of the fact that illumination deserves care and thought and I regard that alone as one of the most important points brought home by this installation!"

School Lighting and Defective Vision.

In an article dealing with defects of vision among the school children of Derbyshire, which appears in *The Medical Officer*, Dr. Sidney Barwise, the County Medical Officer, calls attention to one most potent cause of eyestrain, viz., allowing the child's work to be too near to him. This may arise through insufficient illumination—"the child may bend over his book because the lighting is defective." His experience also seems to confirm the suggestions of Dr. Kerr in his L.C.C. Report,* with reference to the cramped attitude assumed by children owing to the light coming from the wrong direction.

Another difficulty is that the desk does not always fit the child, so that if he is too big, he has to bend over his work, or if too small his work is too near his eyes. Dr. Barwise also suggests that it would be desirable to fit wheels to one end of the desks, so that they could be easily wheeled from room to room as occasion required; there could then be less excuse for wrong positions from the lighting point of view.

* *Illum. Eng.*, Vol. iii., p. 612.

Short Notes on Illuminating Engineering.

From all Sources.

The Maintenance of Lamps by Gas Companies.

THE following extract serves to confirm the note on the same subject in our last number:—

As soon as a lamp becomes the property of the storekeeper he wants to take care of it himself, and claims he can do it as well as the gas company, and cheaper. This has always proved a failure. Whether he can clean it as well or not, he fails to do so, and the result is he has a dilapidated-looking lamp hanging in his store with mantles broken and globe dirty, which soon becomes an eyesore not only to the storekeeper himself, but every one else who passes by and looks in. The gas company has not only lost the maintenance of the lamp, but a consumer, and perhaps a good one. The chances are that they will never be able to get this man back again as a gas consumer, because he feels he has not received the value of the money he has expended in buying the lamps, and is very dissatisfied with his investment.—*Illuminating Engineer*, New York, September, 1910.

Illuminated Clocks in the Tubes—an Improvement.

IN a recent article in this journal the unsatisfactory methods of lighting the dials of clocks in some of the tube railways was commented upon. It was pointed out that in many cases the face of the clock received no special illumination, and also that it was presented to the eye with a background of enclosed arc-lamps which caused the dial to look absolutely black by contrast.

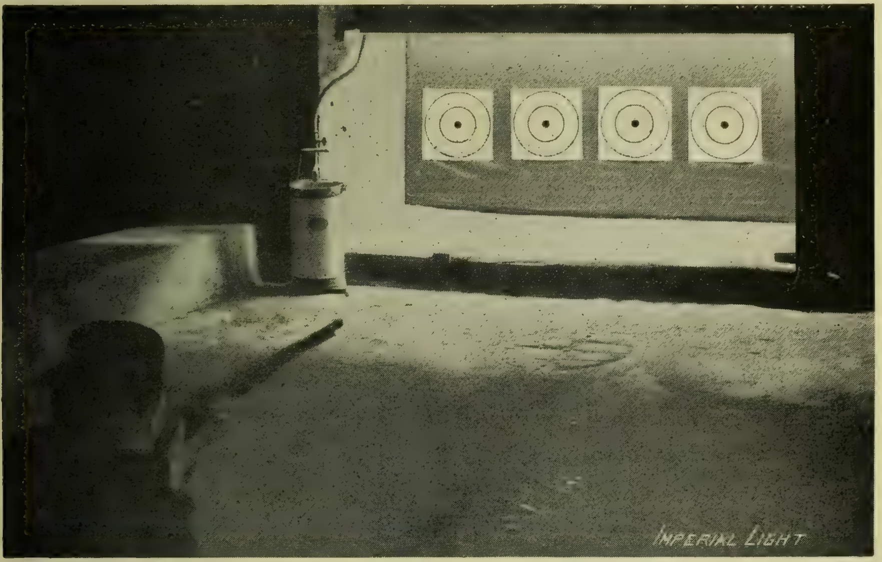
An arrangement is being tried at the Highgate tube station which seems to be an improvement in this respect. The clock has been brought somewhat lower down, so as to be less in the direct line of the arc-lamps referred to, and a shaded glow-lamp has been provided to light up the dial. While the method might no doubt be improved upon, the arrangement seems at least to make the face of the clock easier to distinguish and reduces the obscuring effect of the surrounding glare.

How to Detect "Glare."

GLARE may be roughly defined as such an intensity in a luminous body as to produce indistinct vision of that body. In a general way, the extent of glare is measured by the amount of blurring of the vision, or the time required for the vision to be blurred when constantly looking at the object. Thus, if you look directly at an electric arc the effect on the eye is of seeing simply an intensely bright spot with indistinct outline. Cut down the brilliancy with smoked or coloured glass, and you see that there is no such bright spot, but simply the ends of the carbons in a glowing state. This represents the highest degree of glare in any of the artificial light-sources. On the other extreme, if you look at a common candle flame steadily for a sufficiently long period the outline of the flame will become blurred, but with a normal eye this period would be considerable. This represents the minimum glare among the most familiar light-sources.—*Electrical Review*, N.Y., Oct. 1st, 1910.

Target Lights.

The special value of acetylene as a source of brilliant illumination in situations where there is no supply of ordinary gas or electricity, is exemplified in the case of target lighting.



Rifle ranges are frequently so placed that the provision of illumination cannot be carried out from the public service, and at the same time the intensity of illumination required is exceptionally high. The illustration we reproduce here shows an installation of acetylene carried out by the Imperial Light Co., Ltd., to whom we are indebted for the use of the block. The light is of a portable type, similar to that used on constructional work in Birmingham, to which we referred in a previous number.*

* *Illum. Eng.*, Vol. iii., 1910, p. 448.

More Precise Measurement of Illumination in the Streets Needed

There is now a growing conviction as to the need of precise measurements of illumination, instead of mere statements based on personal impressions. Take, for example, one subject which is receiving very close attention just now in view of the keen competition between different illuminants—namely, street lighting. For a long time the methods adopted of judging whether ratepayers received the due illumination were based on visual impression. That is to say, the councillors paraded the streets and merely looked at the sources. In many cases their judgment of the efficiency of the lighting was based on the intense brilliancy of the source itself rather than on its effectiveness in illuminating the street. Naturally such judgments may be quite misleading....It is, however, interesting to notice that the recent contract entered into between the Gas Light and Coke Company and the Westminster City Council for lighting some of the principal streets established one important precedent in that it was based on the actual candle-power provided by the lamps. Without going into the details of the method of testing prescribed, we may regard this contract as a step in the right direction.—*Times Engineering Supplement*, Nov. 9th, 1910.

The Appearance of Illuminated Signs by Daylight.

A LARGE number of the illuminated signs met with at the present time are by no means as effective in daylight as when they are lighted, and in some cases, as, for example, in ordinary flashing signs composed of a large number of electric lamps, the letters are scarcely sufficiently clear to be read easily in the daytime.

There are other types which have not this failing, but are still not pleasing to the eye when seen by daylight, and it is with a view to remedying this defect that a form of sign, recently described in the *Revue des Éclairages*, has been put on the market.

The letters are constructed in relief out of sheet metal, aluminium or tin, the metal being perforated with a large number of small holes, so that by day the surface of the letters appears quite uniform, and similar to an ordinary metallic sign. At night, lamps are lighted behind the perforations, the letters become luminous, and as the perforations are small and close together, the surface appears uniformly illuminated.

It has also been found possible to use gas flames for the illumination of these signs, and the makers have devised an arrangement of clockwork control which will automatically light and extinguish the gas lamps in the same manner as is done in electric flashing signs.

Flower Baskets on Lamp-Posts.

IT has often been pointed out that lamp-standards, which are so serviceable for illuminating the streets in the night-time, are not always ornamental objects by day. Moreover of recent years the tendency to use sources of very high concentrated brilliancy has involved the use of correspondingly high posts which are much more noticeable objects in the streets than the lower standards of a few years ago.

In our last number we drew attention to the desirability of improved design from the artistic standpoint. Meantime we notice that an interesting private effort to make such posts less unsightly is being made in Philadelphia, U.S.A. Several merchants have volunteered to decorate the posts facing their premises with baskets of flowers hung at half-way up, to keep them in trim, and to renew the baskets with seasonable flowers during the course of the year. In this way, it is suggested, the great height of the lamp-posts will be rendered less noticeable and the display of flowers at intervals will add a touch of colour to the streets and help to render them attractive and pleasant in summer.

Testing the Glare in Street Lighting.

PEOPLE are continually pointing out the glaring effect of many sources used for street lighting. When the eye catches sight of a bright light in the background behind an approaching vehicle its outlines are difficult to distinguish. It is also often almost impossible to recognize an approaching person for the same reason—even when the general illumination is quite high.

Now Mr. P. S. Millar, in a recent contribution to the *Electrical World*,* has described a method of testing the degree of glare in these cases. He points out that the ability of the eye to perceive light and shade is very greatly influenced by glare, and he makes use of a disc having round its rim a graduated scale of contrast.

In using the apparatus the observer first places a dark cloth behind the disc, so as to present a satisfactory background, and notes what contrast can just be detected by the aid of the available street-illumination. Next he removes this cloth, with the result that his eye can perceive stray bright lights, and a second observation is then taken. The observer then finds that he cannot perceive such a minute difference in light and shade as before, and this reduction in acuteness of vision can be taken as a measure of the glare effect.

* *Elec. World*, pp 941-943, Oct. 20, 1910.

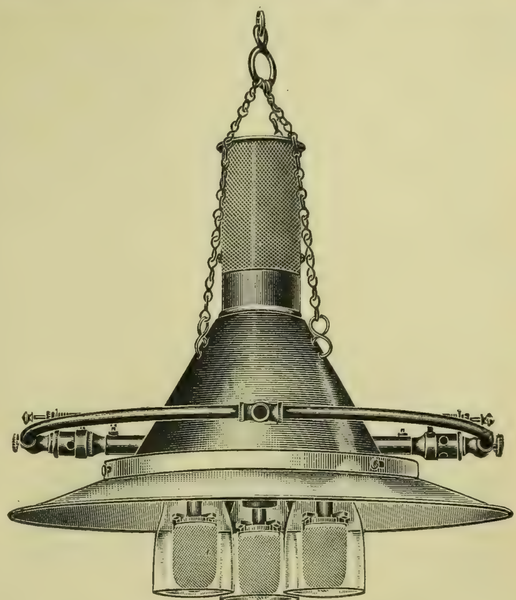
TRADE NOTES.

[At the request of many of our readers we are extending the space devoted to Trade Notes, and are open to receive for publication particulars of new developments in lamps, fixtures, and all kinds of apparatus connected with illumination.

The contents of these pages, in which is included information supplied by the makers, will, it is hoped, serve as a guide to recent commercial developments, and we welcome the receipt of all *bona fide* information relating thereto.]

An Adaptation Set for Converting Upright into Inverted Burners.

Messrs. A. E. Podmore & Co. (34, Charles Street, Hatton Garden, E.C.) have sent us particulars of their "Aladdin" Conversion fittings, which they have brought out with a view to adapting existing upright burners in street or other outside lamps to the inverted system, thereby obtaining the economy of the more modern system with the least possible expense in conversion. The fittings can be hung directly in an existing lantern, the reflector being made to suit, and the lamps can be fitted with any number of burners up to six by means of the ring of tubing as shown in the three-light fitting illustrated here. All that is necessary to fit the lamp is to connect this ring by a bent piece to the original vertical pipe in the standard. The illustration shows one of a large number of fittings of similar type made by this firm.

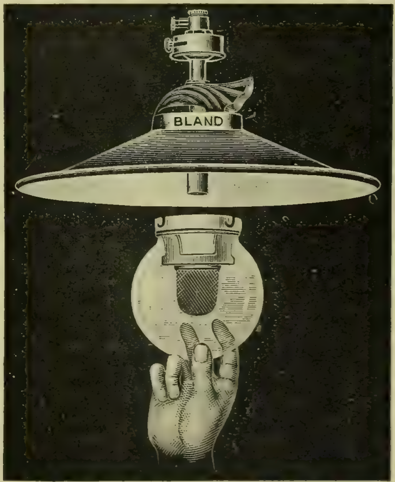


The Bland Light

Several new features have been incorporated in the latest type of inverted incandescent burner made by the **Bland Light Syndicate, Ltd.** (29, Little Trinity Lane, Queen Victoria Street, London, E.C.). In connection with the air admission, a new arrangement, called a dust-cap, has been introduced to avoid the choking of the burner or nipple-point by dust and dirt entering the mixing chamber. The air now enters the cylindrical chamber (seen in the illustration above the protecting shell) from the bottom, and inside this chamber passes through slotted holes in the sides which are downwardly inclined, these holes being closed by an adjustable shutter.

The bunsen and nozzle are now made of hardened steatite, the old steel bunsen being discarded. Special attention has been paid to the quality of the screw threads in the various parts of the burner, as this has been found a source of trouble in the past.

The factory lamp which we illustrate, has been specially designed for situations



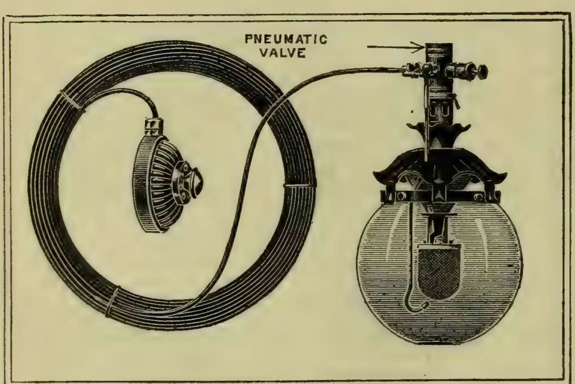
in which there is an exceptional amount of dust.

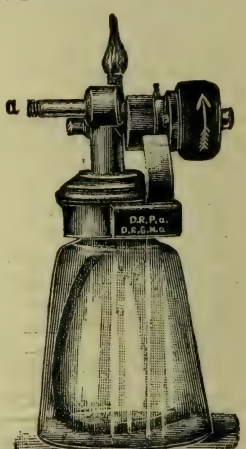
The Automatic Ignition of Gas Lamps.

AMONG the most interesting problems in modern gas lighting may be mentioned that of securing to gas the advantage enjoyed by electricity of automatically kindling and extinguishing lights at a distance. Some very interesting articles on this subject have recently appeared[1] and we take this opportunity of making a brief summary of some of the systems which have been referred to in these columns from time to time and regarding which we have recently received some additional information from the makers.

The subject falls into two divisions—public and interior lighting. The advantage of Gas Companies being able to control their lamps from the station is obvious and quite a number of methods have been devised to enable this to be done. For example clockwork mechanism has been added to the lamp, rendering it possible to extinguish and light public lamps at certain pre-determined times in a very reliable manner. One thing, however, which a purely mechanical clockwork system naturally cannot do is to take an account of the weather. Now, in any emergency, when a fog comes on, for instance, the engineer of the gasworks wants to put his light on at once.

This need has led to other systems of automatic control based upon a temporary rise in pressure in the gas mains. The engineer merely increases the pressure for a short interval and such a rise or diminution in pressure actuates the special mechanism attached to the street lamps and causes them to be lighted and extinguished as the case may be. Quite a number of devices of this kind, many of them based upon the pressure of rising and falling diaphragms have been introduced. For example, we may mention the BAMAG system (**Distance Lighting Co.**, 69, Farringdon Road, London, E.C.). A very interesting discussion on the economies derived by such apparatus recently appeared in the *Journal für Gasbeleuchtung*, and it has been said that by the installation of 4,200 Bamag lighters an annual saving of 2,500*l.* was made in one district. Other devices of this kind, such as the ROSTIN (**A. Landsberger**, Oxford Court, London, E.C.) device, utilising a mercury seal, have also been largely utilized in practice. Both these devices have been described in this journal.[2] Other distance gas lighters include the GASCHO[3] apparatus (**Messrs. Julius Norden**, 45, Farringdon Street, London, E.C.) and the AUTOMATON apparatus of the **Auto Lighter Syndicate**[4] (17, Victoria Street, S.W.) which is claimed to be particularly adaptable to the varying conditions of supply in different districts. While dealing with street lighting we must not forget to mention the method of electrical ignition by means of electrically heated platinum wires which forms a feature of the high-pressure incandescent gas light system of **Messrs. G. Keith & Blackman Co. Ltd.** (27, Farringdon Avenue, London E.C.).





Turning next to indoor lighting, we again find a variety of systems. The

(1) See *Journal of Gaslighting*, Sept. 13 and Oct. 4, 1910, J. H. Seager, *Illuminating Engineer* of New York, Aug. 1909, &c.

(2) *Illum. Engineer*, London, Vol. II., 1909, pp. 255, 257.

(3) *Illum. Engineer*, London, Vol. III., May, 1910, p. 349.

(4) *Illum. Engineer*, London, Vol. III., June, 1910, p. 411.

NORWICH[5] system of **Messrs. G. Hands & Co.** (71, Farringdon Road, London, E.C.) makes use of a special valve at the nose-piece of the fitting, which is opened by the pressure of the gas supply when the tap is turned on.

The system of the **Pneumatic Gas Lighting Co.** (36, Farringdon Street, E.C.) makes use of the application of a pneumatic pressure afforded by merely turning on a switch ; this again, actuates a special valve and permits a flow of gas which is ignited by the bye-pass. The method is stated to have been used with complete success in private houses ; the small amount of pressure required will be understood from the little switch shown in the illustration which closely resembles those of the ordinary tumbler type used in electric lighting. The method can also be applied to other purposes such as pneumatic door bolts, &c.

Such a system, of course, implies the use of a byepass. In the TELEPHOS system (**The Telephos Co.**, 16, Farringdon Avenue, E.C.), however, a byepass is not necessary. Electric wires are run to the burner terminating in a small platinum wire, placed where the gas is to be kindled. The pressing of the switch closes the circuit enabling current to be supplied from dry cells to this wire, heating it to incandescence. Simultaneously the flow of the electric current admits the gas by actuating an electro-magnetic device, and the burner lights up.

Two other systems deserve mention. One of these is the SELF-LIGHTING MANTLE utilizing a pellet of special material which becomes incandescent when gas flows over it.[6] The other is the PYROPHORIC SYSTEM, in which the sparks obtained by rubbing a special mineral, cerite, are utilized. The use of this principle in the gas-igniter supplied by **Messrs. Julius Norden** has also been described in this journal.[7] The illustration shows the "flask-igniter" made by the same firm, in which the method is applied to kindling a small spirit lamp. In a recent article by H. Wunderlich it was stated that the pyrophoric system had been applied experimentally to the distant control of gas lamps in Germany.[8]

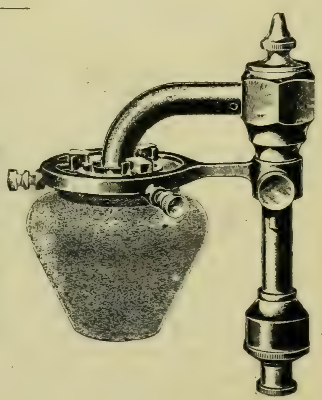
The above note summarizes a few of the most interesting methods of securing distance control of gas lights. As explained, many of these systems have been referred to in previous numbers of this journal ; further particulars can also be secured by application to the firms named above.

(5) *Illum. Engineer*, London, Vol. II., 1909, pp. 254, 258.

(6) *Illum. Engineer*, Vol. II., 1909, p. 254.
(7) „ „ „ „ p. 780.
(8) *Journal für Gasbeleuchtung*, May 15, 1909.

The Howellite Inverted Incandescent Burner.

This burner, which is made by **Messrs. Howellite Burners, Ltd.**, (22, Farringdon Avenue, London, E.C.) is, we understand, specially suitable for producing photographic enlargements, when used without a globe. It is also stated that the air supply and the position of the mantle in the flame can both be controlled so as to get the best possible illumination, and the mesh of the mantle which has formerly given trouble by showing in the enlargement, is said to be quite invisible, when the lamp is burning with full brilliancy.



We may also refer to the conversion fittings made by **Messrs. Julius Norden** (44, Farringdon Street, London, E.C.), and we would call attention to the cylindrical lantern which they make for inverted burners, in which two halves are clamped together to form the complete cylinder. By releasing a catch the two portions come apart, and are readily detached for cleaning, &c.

Other Items.

The **British Thomson-Houston Co., Ltd.** (Rugby, and 83, Cannon Street, E.C.) send us a pamphlet dealing with their Induction and Prepayment Meters.

We have received a list showing the various types of Lifts made by **Messrs, Alex. Chaplin & Co., Ltd.** (Helen Street. Govan, Glasgow).

A Visit to Messrs. Sugg & Co.'s Works.

A visit of the London and Southern District Junior Gas Association took place on November 25th to the works of **Messrs. William Sugg & Co., Ltd.,** Westminster. We have received a programme of the proceedings, which opens with an historical account of the development of the firm, and refers to the adoption of the Argand burner as the standard test burner by the Gas Referees in 1869.

The second part gives details of the work carried on in the various departments that were visited—brass finishing shop, iron and brass foundries, engineers' shop, &c. It is interesting to note that in the steatite shop, besides the usual nozzles for gas burners, Messrs. Sugg & Co. turn out insulators for all kinds of electrical work, and we notice in another department that sparking plugs are manufactured. Finally we may mention the photometer room, where photometers of all kinds, calorimeters, and other meters are tested.

The "Aladdin" Lamp for Street Lighting.

Attention is directed to the "Aladdin" gas lamp, with inverted burners, as the best form of this class of street lamp for use on an ordinary lamp post. It is claimed to be shadowless and to yield a lighting power of approximately 120 c.-p. per burner with the low consumption of 3½ cubic feet per burner per hour. Whilst the head is hinged, so as to admit of ready access to the interior, it is constructed in such a manner that it is absolutely wind and weather proof, and the reflector, of convex form, ensures the diffusion of light over a much wider area than would otherwise be possible.

These lamps can be inspected at the showrooms of **Messrs. Falk, Stadelmann & Co.,** who, we understand, have now on exhibition a variety of other novelties of interest to the illuminating engineer.

The Welsbach Incandescent Gas Light Co., Ltd., have sent us a copy of their latest Price List (1910–11), which contains 150 pages dealing with the various fittings, burners, mantles, &c., suppliedby this firm.

Spon's Architects and Builders' Pocket Price Book. — The 1911 edition will be ready early in December. The book has been divided into two sections :—

Memoranda and Tables, containing a large amount of useful information in a handy and portable form.

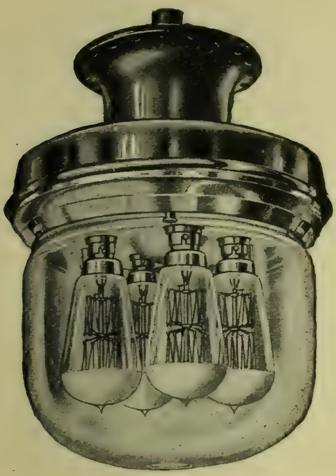
Prices and Diary, in which the prices have been carefully revised to date.

Messrs. Siemens Bros. Dynamo Works, Ltd., send us a copy of their revised price list of "Onewatt" Lamps, and point out that they are now placing on the market a new 200 C.P. Lamp, which will have the same efficiency and general characteristics as the present 100 c.-p. "Onewatt" lamp, and will be supplied at prices which compare very favourably with those of other types of high c.-p. lamps on the market.

The Lighting of Newport Technical Institute.

The above illustration shows the scheme of illumination adopted in the Hall of the Newport Technical Institute. The whole of the lighting has been carried out with Holophane fittings supplied by **Messrs. Siemens Bros. Dynamo Works, Ltd.** High candle-power 'Onewatt' Tungsten Lamps are used in the large central Holophane spheres, with Tantalum Lamps in the smaller globes. The installation is a good example of Holophane lighting.

Messrs. Siemens Bros. Dynamo Works, Ltd. (Tyssen Street, Dalston, London, N.E.) send us illustrations and particulars of two outside weatherproof Lanterns, one of which, designed for a cluster of four "Tantalum" Lamps, we reproduce here. One of the features of this design is the patent



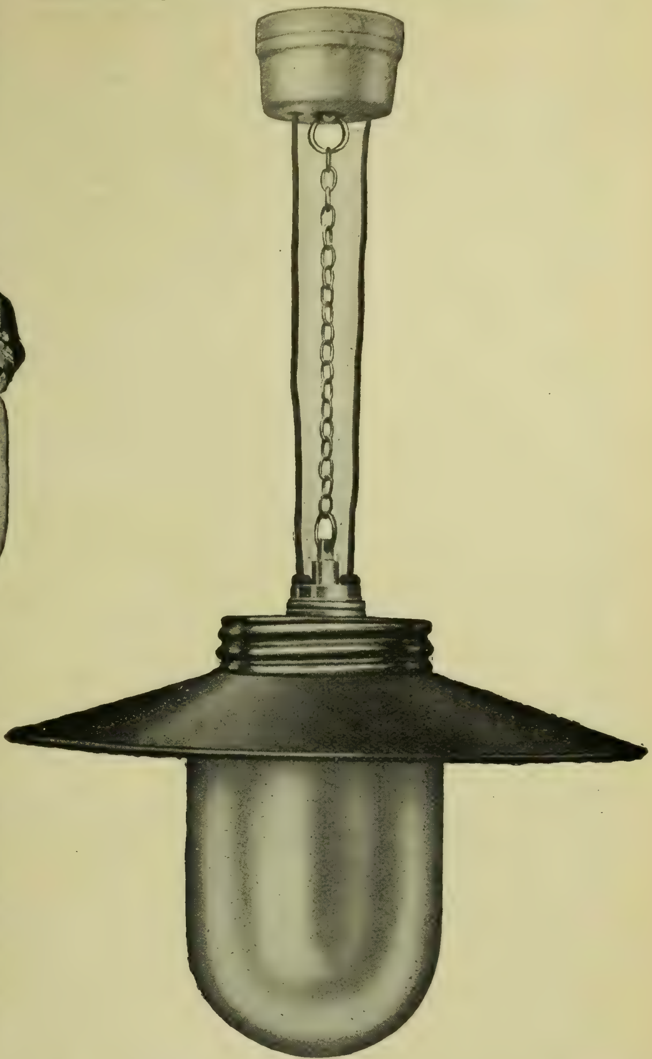
self-locking device for the globe, which makes set-screws for globe fixing no longer necessary, and should reduce breakage from this cause.

Messrs. Siemens also send us a pamphlet dealing with the **Holophane "Stiletto"** Reflectors which we referred to in our last number, and the new special screwless gallery. We note that this firm have made arrangements for additional telephone lines to be installed to deal with the pressure of business.

The same firm have also sent us a full and compact catalogue of Arc Lamps for Continuous and Alternating Currents, together with a pamphlet on the 'Development of Flame Arc Lighting.' The catalogue deals fully with Open, Enclosed, and Flame Arc Lamps, as well as with Resistances, Transformers, and other Accessories.

A NEW ELECTRIC PENDANT.

Messrs. Simplex Conduits, Ltd. (113–117, Charing Cross Road, London, W.C.) have introduced a pendant in which, it is claimed, all strain on the flexible or terminals is eliminated, and risk of fire or accident from falling lamps is reduced to a minimum. In



the factory type which we illustrate the weight of the lamp is taken by a chain. A special ceiling-rose has been designed which serves the double purpose of supporting the lamp independently of the wires and separating the poles, thus minimising the risk of short circuit due to bad insulation.

A CORRECTION.

We regret that a misprint occurred in the advertisement of **Holophane, Ltd.**, on the back of the wrapper of the last number of this journal. The words "see page ii" ought to have been "see page v," thus referring to the advertisement of the new **Stiletto** Reflectors of this firm.—Ed.

CORRESPONDENCE.

Spectral Energy Curves of the Moore Tube.

SIR,—With reference to the suggestion of the desirability of obtaining spectral energy curves of the Moore tube and of the flaming arc with calcium and other metallic vapours, I would call the attention of the correspondents to the fact that the "Moore tube" is simply a gigantic "Geissler tube," or ordinary vacuum tube, containing nitrogen, or carbon dioxide, or mixtures of such gases; hence, the information sought may be found in the spectral energy curves of these gases, published in a recent number of *The Illuminating Engineer.* In the same manner some idea of the flaming arc spectral energy curves may be obtained from the experiments on the emission spectra of metals, *e.g.*, Ca, Na, Li, &c., in the carbon arc, examples of which may be found in this same journal—also published *in extenso* in Publications of the Carnegie Institution. WM. W. COBLENTZ.

Some Publications Received.

The Illumination of Study Rooms. By A. L. Parsons and H. W. Smith.
THIS is a very detailed report of the present system of lighting employed in the study rooms of a U.S. Naval Academy, with suggestions for its improvement. Out of 25 pages, 16 are devoted to a close study of the general considerations, and in the appendix a large number of diagrams and tables are given, dealing with the distribution of illumination and the colour scheme in the rooms, &c.

Visual Phenomena connectcd with the Yellow Spot. By Dr. F. W. Edridge-Green.
IN this communication, which is a reprint from the *Journal of Physiology*, the author considers some of the phenomena of the Yellow Spot, such for example, as the whirling currents which are seen in the field of vision when the eyes are partially or totally closed. A theory is put forward to explain these phenomena.

Elektrische Beleuchtung. By Dr. B. Monasch.
THIS is Part 2 of the book to which we referred in our last issue, and which we hope to review in detail shortly.

Luminous and Flame Arcs versus Open and Enclosed Carbon Arcs for Street Illumination. By W. D'A. Ryan.
THIS paper, which was read before the National Electric Light Association last May, deals exhaustively with the subject of street lighting by Arc Lamps. It is fully illustrated with photographs and coloured diagrams. We hope to refer to it in greater detail in a later number.

Holophane Illumination is a new publication issued by **Holophane, Ltd.** (12, Carteret Street, Queen Anne's Gate, S.W.), in order to popularize scientific illumination and to describe the most recent novelties in connection with Holophane glassware. The first number contains a summary of the chief qualities of the "E," "I," and "F" type reflectors, written in an attractive and readable manner. The first of a series of 'Holophane Homilies' is addressed to the contractor and emphasizes the opportunity awaiting those who are prepared both to provide the most up-to-date illuminating apparatus and also to give competent advice as to how it can be used. The publication contains a note on church-lighting and particulars are also given of a number of recent installations. We must congratulate Holophane, Ltd., on their enterprise in issuing a publication in which the claims of good illumination are so attractively put forward.

Among other publications we have also to acknowledge the receipt of the following:—*The Journal of the Royal Society of Arts, The Journal of the Rontgen Society, The Transactions of the Illuminating Engineering Society (U.S.A.), The Transactions of the South African Institute of Electrical Engineers, The Proceedings of the American Institute of Electrical Engineers, Proceedings of the American Academy of Arts and Sciences, The Physical Review, American Chemical Journal, Proceedings of the Tokyo Mathematico-Physical Society, Sitzungsberichte der Königlich Bayerischen Akademie der Wissenschaften.*

Review of the Technical Press.

ILLUMINATION AND PHOTOMETRY.

There have been far more papers in this section than can be even mentioned. A number of these were read at the Convention of the Illuminating Engineering Society in the United States. Some are referred to in the Editorial in the present number.

Thus **P. S. Millar** lays stress on the importance of studying the NATURE OF SURFACES IN THE STREETS, besides the location of the sources. The same author has also described, in *The Electrical World*, a DEVICE FOR TESTING GLARE in the streets based on the amount of contrast which the eye can just detect. P. S. Millar has also been pointing out the part played by the "silhouette principle" in observing people and vehicles in the streets. In many cases one only sees objects as jet-black silhouettes, owing to the bright sources behind them.

E. P. Hyde's PRESIDENTIAL ADDRESS was largely devoted to a study of the efficiency of light production and the nature of the radiation in different parts of the spectrum. A similar subject was dealt with by **H. E. Ives** (*Elec. World.*, Oct. 13) in discussing the NATURE OF FIREFLY RADIATION. He has made detailed tests in order to ascertain whether the light is, strictly speaking, of a phosphorescent nature; it appears that the usual tests of phosphorescence are not complied with. On the other hand, new and refined investigations show that the efficiency is extremely high, for very little trace of wasteful non-luminous energy can be detected. The question is also taken up in correspondence by Elihu Thomson and Coblentz in subsequent numbers of *The Electrical World.*

There are also innumerable articles dealing with the illumination of paper mills, bowling greens, and installations of various kinds, &c., in *The Illuminating Engineer* of New York and other journals. An illustrated article in this journal deals with the moving camera as a means of studying glare, the supposition being that it is only when a certain intrinsic brilliancy of the image is attained that streaks are recorded on the photographic plate.

Schreckenburg (*Elek. u. Masch.*, Nov. 27) points out some interesting qualities of the ULTRA-VIOLET RAYS in causing chemical action notably among organic materials. He also gives data regarding their transmissibility through various liquids and solutions.

ELECTRIC LIGHTING.

One of the most interesting examples of electric lighting described during the past month has been the lighting of the NEW HOME OF THE INSTITUTION OF ELECTRICAL ENGINEERS (*Electrician*, Nov. 11; *Elec. Rev.* Nov. 11); this, however, has already been referred to in this number.

A comprehensive paper on STREET LIGHTING WITH MODERN ELECTRIC LAMPS was also read before the Institution of Electrical Engineers by **Haydn T. Harrison,** and is abstracted in various electric journals (*e.g. Electrician*, Nov. 25). The paper contains detailed tables connecting the cost of gas and electric incandescent lamps and a number of polar curves of light distribution which illustrate modern contrivances for modifying the natural distribution of light from sources. Emphasis is also placed on the need for avoiding glare, and this was also frequently referred to in the discussion.

C. L. Kinsloe (*Elec. World*, N.Y., Oct. 13) describes some striking results regarding the EFFECT OF WAVE-FORM on the performances of incandescent lamps on alternating current circuits. He finds that a peaked wave tends to decrease the life of a lamp by 25 to 50 per cent of what it would have been with a sinusoidal curve, and that the efficiency is also reduced.

H. Gage gives the results of some experiments on PROJECTION ARCLAMPS. He finds that continuous current lamps are invariably more efficient than alternating current ones from the standpoint of light, and that a rectified alternating current is almost as good as a strictly continuous one.

Among other articles we may note one on STAGE LIGHTING in *The Electrical Times*, in which a novel method of directing light on the stage by means of

sources in the auditorium is mentioned. Other items include general articles on incandescent lamps by **Cheneveau,** and on the QUARTZ TUBE MERCURY LAMP by **M. Leblanc** (*Lumière Electrique,* Nov. 5). The latter author enters into the nature of the processes within the tube, and adds some effective illustrations. The serial article on NEW FORMS OF ARC LAMPS is continued in the *Zeitschrift für Beleuchtungswesen,* the most recent portion dealing with magazine arc lamps.

GAS, OIL, AND ACETYLENE LIGHTING.

The most important contribution in this direction is the paper by **F. W. Goodenough** before the Illuminating Engineering Society (London). This is dealt with in the present number, and was also treated in recent issues of *The Journal of Gas Lighting* and *Gas World.*

The question of the STANDARD BURNER BILLS has aroused much attention, but still receives comment. The Bills in question have now been passed in the House of Commons.

Several articles deal with HIGH-PRESSURE GAS LIGHTING in Birmingham and elsewhere. In this locality the pressure in the mains is stated to have been as high as 140 in. of water. **Lebeis** (*J.f.G.,* Nov. 12) contributes a general article on PROGRESS IN GAS LIGHTING. He gives details of several new lamps, notably an improved form of upright lamp, and contends that the merits of the upright, as compared with the inverted burner, are not properly appreciated. **F. Messenger** (*J.f.G.,* Oct. 29) contributes a more general article summarizing the progress of gas lighting, the intention being to disprove the suggestion that in the future gas will come to be mainly used for heating rather than lighting purposes.

A new field for gas lighting is described in a recent number of *The Journal of Gas Lighting,* namely, the use of GAS FOR ILLUMINATED SIGNS. This department, it is suggested, deserves more detailed study.

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Indirect Lighting of Theatre Auditorium (*Elec. Rev.,* N.Y., Nov. 8).
Relative Glare shown by a Moving Camera (*Illum. Eng.,* N.Y., Nov.).
The last word in Department Store Illumination (*Illum. Eng.,* N.Y., Nov.).
The New Building of the Inst. of Electrical Engineers (*Elec. Rev.,* Nov. 11; *Electrician,* Nov. 11).
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Special Street Lighting in Washington (*Elec. World,* Oct. 20).
Baltimore Convention of the Illuminating Engineering Society (*Elec. World,* Oct. 27).
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High Pressure in Industrial Birmingham (*G.W.*, Oct. 29).
The Lighting of Important City Thoroughfares (*G. W.*, Oct. 29).
Illuminated Advertisement Signs and Incandescent Lighting (*J.G.L.*, Oct. 25).
Incandescent Acetylene Burners (*Acetylene*, Nov.).
Lighting Mines by Acetylene (*Acetylene*, Nov.).

CONTRACTIONS USED.

Elek. u. Masch.—*Elektrotechnik und Maschinenbau.*
E. T. Z.—*Elektrotechnische Zeitschrift.*
G. W.—*Gas World.*
Illum. Eng., N.Y.—*Illuminating Engineer of New York.*
J. G. L.—*Journal of Gaslighting.*
J. f. G.—*Journal für Gasbeleuchtung und Wasserversorgung.*
T. I. E. S.—*Transactions of the Illuminating Engineering Society* (*United States*).
Z. f. B.—*Zeitschrift für Beleuchtungswesen.*